

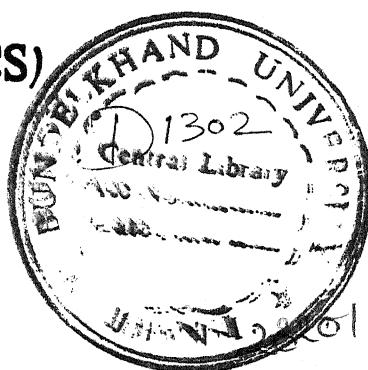
SUPRACONDYLAR FRACTURE OF THE HUMERUS-A CONSERVATIVE APPROACH

THESIS

For

MASTER OF SURGERY

(ORTHOPAEDICS)



**BUNDELKHAND UNIVERSITY
JHANSI (U. P.)**

1998

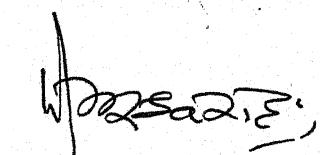
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CERTIFICATE

This is to certify that the work entitled " SUPRACONDYLAR FRACTURE OF THE HUMERUS - A CONSERVATIVE APPROACH" has been carried out by Dr. Alok Johri, himself in this department.

He has put in the necessary stay in the department as required by the regulation of Bundelkhand University.



(P.K.Dabral)
M.S.

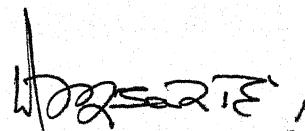
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CERTIFICATE

This is to certify that the present work entitled "SUPRACONDYLAR FRACTURE OF THE HUMERUS - A CONSERVATIVE APPROACH" which is being submitted as a thesis for M.S. (Orthopaedic Surgery) was carried out by Dr. Alok Johri, under my constant supervision and guidance.

The techniques embodied in this work were undertaken by the candidate himself. The results and observation were checked and verified by me periodically.


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Guide

Foreword

At the time of allotment of topic for thesis, initially I had one goal in mind; to work on a subject which had operative management as the mainstay of treatment. I discussed various tentative subject with my guide who felt that the supracondylar fracture of the humerus in children with its various modes of treatment, each promising to be better than the others would be a very interesting one to work on.

When my guide suggested the present subject as a topic for thesis, I was rather disappointed as most others would be at my age. For one topic was 'conservative', 'non surgical'. Moreover it was difficult to believe that a change in position of the forearm from supine (which is the position described in text) to prone would make much difference. Going through the literature made me realize that the topic was intriguing and challenging. However, it still could not change my perception that the results of open reduction and internal fixation would give the best results as any fault in reduction would not be possible and the internal fixation would prevent any possibility of redisplacement and thus no deformity would occur. As study progressed even this perception eroded.

Alok Johri

Acknowledgements

It was my proud privilege to have the opportunity to work under the supervision of Prof P.K.Dabral (M.S.) Professor & Head of the Department of Orthopaedics, MLB Medical College, Jhansi. I can not express my indebtedness and gratitude for him with my vocabulary. I remember the numerous fatherly allowances he rendered me by sparing time to go through details of the thesis providing valuable inspirations & suggestion. It leaves me short of words to reflect even a fraction of his infinite blessings.

In no less degree, I owe my most sincere thanks to Dr. R. P. Tripathi (M.S.) Asso Prof, Deptt of Orthopaedics M.L.B.Medical College. & Dr D.K.Gupta (M.S.) Asstt. Prof. Dept. of Orthopaedics M.L.B.Medical College, Jhansi, for their expert guidance, valuable advice and trusted help at every juncture. I also wish to thank Dr. G.M. Lal, S.S.P.G. Hospital Varanasi for the various articles he provided me on the subject.

I also wish to express my sincere thanks to my brother Anurag, who untiringly surfed the internet to provide me with bountiful of literature on this topic and Mr. Prabhat Saxena a novel entrepreneur for his sincere efforts in converting the non legible manuscript to this presentable form.

Last but not the least I wish to acknowledge my parents who have sacrificed a lot of their worldly desires to make the dreams of their children come true, and my wife for the frequent nagging when my progress through the work declined helping me keep pace. I also wish to acknowledge the help provided by my colleague Dr. Vineet Raj & Mr.B.K. Dixit, plaster technician, Deptt. of Orthopaedics for helping me throughout this work.

24/5/98
Dated


(Alok Johri)

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INTRODUCTION

INTRODUCTION

(1)

Supracondylar fracture of the humerus in children is one of the most common injuries of this region in childhood and though the fracture in most cases unites uneventfully ('when Watson Jones stated "The prognosis of supracondylar fractures is excellent" he must have been speaking of function not of form' - **Lyman Smith M.S.**) there is a high rate of occurrence of residual deformities following its malunion, and though a number of treatment modalities have developed, since times immemorial, each have their limitations and the dilemma continues as to which treatment modality would best serve a particular case of a displaced supracondylar fracture of the humerus taking all factors into consideration and though the recent trend is towards closed reduction and percutaneous pinning, certain studies cast doubt on its being the sole treatment option in all cases and in all situations ; a brief review of the history of the treatment options that developed over the years follows :

The various treatment modalities for the supracondylar fractures of the humerus in children have developed with the aim of reducing / preventing the frequent complication of residual deformity (most commonly cubitus varus specially in the more displaced Type III & IV fractures. An analogy can be drawn between this goal and the aim of prevention of non union in cases of fracture neck femur where the treatment armamentarium is even larger .

Closed reduction and immobilization by traditional means has a long history, finding its strong support in veterans such as Sir Astley Cooper(1826), Sir

(2)

Robert Jones (1921), Watson Jones (1952 -55) and Sir Charnley (1961), and is still widely accepted as an ideal treatment of supracondylar fractures of humerus fresh or old; however the instability of the reduction, which increases as the initial swelling subsides is high.

With the aim of reducing the frequency of deformity most importantly varus (often called the necessary evil) as a post treatment complications, Dunlop, for the first time in 1939 described the role of traction in the treatment of supracondylar fractures of the humerus. Initially he gave a straight lateral traction, and to his surprise the fragments were in perfect position; later he started giving a vertical counter traction on the arm with traction in a semiflexed position of the elbow.

Dunlop's method was found inconvenient and tedious as it required check x-rays and an eye on maintainance of the carrying angle though, later Allen and Gramse (1945), Dodge (1972), Jefferis (1977) and Alberger (1992) found traction to be a useful method.

Watson Jones (1952 - 55) opined that traction be given for 3 to 5 days and be followed by reduction of the fracture under anesesthesia after the swelling has subsided, and the reduction maintained by immobilization is full flexion.

James Piggot (1986) found better results if traction for three weeks was

(3)

followed immediately by active exercises under supervision.

Traction has been summarised into two groups :

- (a) Skin Traction -
 - In flexion - (i) Dunlop (1939)
 - In Extension -(i) El Sharkawi and Fatteh (1965)
 - (ii) Jefferis (1976)
 - (iii) Bosanquet and Middleton (1983)
- (b) Skeletal Traction - (In flexion only)
 - (i) Smith (1947)
 - (ii) Palmer et al (1978)
 - (iii) Worlock and Colton (1984)

Though none of the traction methods claimed an accurate reduction the alignment, length and carrying angle were all well controlled under vision and by AP x-ray. During the period of skin traction treatment deformity could be corrected from time to time. In skeletal traction in flexed position however these advantages were not there and there were added disadvantages of pintract infection and damage of the ulnar nerve by the implant.

A problem with all the methods was the 3 weeks hospitalization of a child whose activity was difficult to restrict in bed even for a day, not to forget the increase in hospital load by the long stay at hospital. Moreover, both the conservative reduction and immobilization, and the traction methods were useless in the unreduceable type II & type III fractures due the fish tailing of the proximal fragment

(4)

(which sometimes gets trapped in to the surrounding soft tissues and skin anteriorly). Open reduction and fixation of the fracture with K wire or plates and screws, thus found its advocates in Carcasonne et al (1972) Ramsay & Griz (1973), Hart et al (1978), Danielsson & Patterson (1980), Kekomalu et al (1984), P.P.Kotwal et al (1989) and Lal & Bhan (1991) who found the distinct advantages in open reduction and internal fixation viz.

(i) Accurate reduction

(ii) Avoiding all the disadvantages of the extreme positioning of elbow.

(iii) A well maintained carrying angle due to absence of redisplacement.

However a strong adversary of open reduction, Watson Jones condemned the procedure on the grounds that:

(i) It is a difficult procedure

(ii) It does not provide any added advantage, rather it adds the disadvantages

of

(a) Post operative infection

(b) Myositis ossificans

(c) Stiffness of joint due to the capsular fibrosis

Thus developed a compromise between the traditional closed reduction with POP and operative methods in the form of closed reduction and pinning to stabilize the fracture.

(5)

One of the factors contributing to its development was the improved per opertaive radiological assessment possible with the biplanar image intensifier. The advantages of this technique include:

- (i) It avoids the extreme positioning of the elbow
- (ii) Reduces the duration of hospitalization
- (iii) later displacement and change in carrying angle are prevented

However the method is not without disadvantages viz :

- (i) Pin tract infection
- (ii) Nerve injury (specially of the ulnar nerve)
- (iii) It requires, for the best results, an image intensifier the formidable cost of which precludes its use in third world countries like ours.
- (iv) Recent studies as one conducted by Hadlow A.T. et al (1996) have shown that if the recent trend of pinning all type II & type III fractures is followed 77% of type II and 61% of type III would be pinned needlessly. Thus the current trend towards pinnig of all type III supracondylar fractures is not supported by some recent studies.
- (v) Perhaps the most dificult and unsolved problem in the treatment of supracondylar fractures is the dificulty in assessing both the preopertaive deformity present and the assesment of reduction peropertaively by x-rays. According to Campbell the three most common reasons for deformity are:-

(6)

- (a) Inability to interpret poor x-rays thus accepting inadequate reduction
- (b) Inability to interpret good x-rays because of poor knowledge of pathophysiology of this fracture.
- (c) The loss of reduction

In conclusion, it is clear that though the treatment of type I fractures is clearly closed reduction and casting, the treatment options for the displaced types of fractures is controversial. Considering the high costs of other method in a third world country like ours, with not adequate health care facilities in the periphery, treatment of these troublesome injuries, even in displaced fractures remains closed reduction and casting in most cases.

I have chosen this thesis for the following reasons :

- (i) It is the commonest injury of elbow in children
- (ii) It is one of the difficult fractures to treat.
- (iii) It may show all grades of vascular and neurological complications and if the treating surgeon is not vigilant even limb loss may occur, chances of which increase, the longer the time is spent between injury and treatment, the time being taken to transport the patient to a higher sophisticated treatment centre.
- (iv) Even if treated effectively it leaves in the wake of its healing deformities like cubitus varus or the gunstock deformity.

(7)

Aims of Study:- The Study was conducted with the following aims:-

- (i) To assess the incidence (with respect to age, sex etc.) of displaced supracondylar fractures of the humerus in children in Bundelkhand region.
- (ii) To study the incidence of complications (i.e. immediate, early and late) in supracondylar fractures of the humerus in children of Bundelkhand region treated conservatively.
- (iii) To evaluate the role of closed reduction maintained by an above elbow plaster of paris cast in hyper flexed elbow in the prone & supine position of the elbow. in supracondylar fractures of the humerus.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Epidemiology :- Supracondylar fracture is the commonest elbow injury in children accounting for 80% of total paediatric fractures; 99% of these (variously quoted as 97.7%¹³ and 99%)⁶ are of the extension type, ie posteriorly displaced and the rest are flexion type or anteriorly displaced; about 1% of the total fractures are compound injuries.³⁸

Incidence with regards to age sex side and seasonal variations :

Supracondylar fractures occur between the 3rd to 12th year of life.³⁸ Some quote a clustering of cases in the 7.5 year's age group.³⁸

Bongers K.J.(1994) stated that there was a bimodal age of presentation of supracondylar fractures;⁸ one peaking in childhood and the other in advanced age in the elderly; in the latter group he claimed that the treatment is even more difficult as conservative treatment leads to stiffness and restricted functions while the usual operative methods are difficult to perform.

It is commoner in boys than in girls in all age group except the very young where the difference is not significant.³⁸

Left elbow is involved in 63% of cases and the peak incidence is in summer.³⁸

Mechanism of Injury :- Extension type of supracondylar fractures is produced by a fall on the outstretched hand with the elbow a little flexed and the fore arm pronated.

Wilkins (1991) described three predisposing factors :

(i) Bony architecture of the lower end of humerus in the susceptible age group:

The supracondylar area in children consists of lateral and medial columns of bone joined by an osseous membrane which forms the coronoid fossa anteriorly and olecranon fossa posteriorly; thus there is an inherent weakness in this area.

(ii) Ligamentous laxity which allows hyper extension of the elbow:

In 1978, Harris I and William J.F. concluded from their clinical and biomechanical study that though forced hyper extension of the elbow was the common mechanism of injury; children who had supracondylar fracture also presented with excessive hyperextensibility of the elbow (by comparing the range of extension of unaffected elbow with elbow of unaffected children) the association was stronger than could be explained by coincidence. This predisposed them to this injury.²³

(iii) Relationship of joint structures in hyperextension due to fall on the outstretched arm :

As the elbow is forced into hyperextension the olecranon impinges in its fossa serving as the fulcrum for these fractures; the collateral ligaments and the anterior joint capsule also resist hyperextension transmitting the stress to the distal humerus and initiating the fracture.¹

Abraham et al (1982) experimentally demonstrated that if force is exerted on the hyperextended elbow it is transmitted to the anterior aspect of elbow through the olecranon fossa, where the bone has been further weakened due to metaphyseal remodelling.¹

In extension type of supracondylar fracture, the fracture line is either transverse or oblique from front upwards and backwards with anterior angulation and posterior displacement.⁴⁵ The commoner 75% of displaced fractures are displaced medially with lateral angulation and medial rotation, the less commoner 25% show lateral displacement with medial angulation and lateral rotation.³⁸

Abraham et al (1982) described that a 'hem of periosteum' ie the anterior periosteum of the humerus is stretched over the distal end of the proximal fragment where as the posterior periosteum remains intact. A similar periosteal hinge has been described on the medial side also.¹ Supracondylar fractures show displacements of all grades. Holmberg (1945)described the grading which is widely accepted.²⁵

Type I fracture with no displacement, ie either there is a green stick fracture or complete fracture with displacement which has spontaneously reduced by it self.

Type II posterior displacement along with medial displacement with or without angulation .

Type III along with posterior and medial displacement fragment is rotated yet

it is in contact with the upper fragment .

Type IV total loss of contact between the fragments with considerable displacement .

Gartland has classified fractures as :²²

Type I - un/minimally displaced

Type II - displaced with posterior cortex intact.

Type III - completely displaced with no cortical contact.

The modified Gartland system of classification classifies¹⁵

Type I fractures further into

I A un displaced or minimally displaced .

I B minimally displaced, medial impaction.

Acute Complications of Supracondylar Fractures:

Associated acute injuries of the supracondylar fracture include, damage to the surrounding soft tissue structures as well as other ipsilateral upper extremity fractures. the soft tissues injured lead to the acute complications viz :

- (i) Nerve injury either isolated or associated with
- (ii) Vascular injuries

(i) Nerve Injury - Recent reports suggest that the incidence of neurological deficits following supracondylar fractures of the humerus has been

underestimated in past reports.⁴⁸

The reason for the discrepancy is that the most commonly involved nerve is the anterior interosseous branch of the median nerve and as the deficit is only motor it is frequently over looked.⁴⁸ The incidence of neurological deficit has been variously reported between 5 -17%.¹⁶

Dormano J.P. et al²⁰ in their review of 200 type III extension supracondylar fractures of the humerus found an incidence of 9.5% (19 patients.) while Brown IC and Zinar DM report its incidence in fourteen of their one hundred and sixty two patients with supracondylar fractures.¹¹

However in a retrospective review of 101 patients with this fracture Cramer KE et al identified 15 patients with neural lesions. All the fractures were displaced extension type.

Yet another study of 101 patients with this fracture found 18 acute neural lesions in thirteen of the children with some having combinations of nerve injuries.⁴⁰

Probably the highest figures quoted are by Campbell C.C. et al who found the incidence as high as 52% (29 of the 59 consecutive type III Supracondylar fractures of humerus in children).¹²

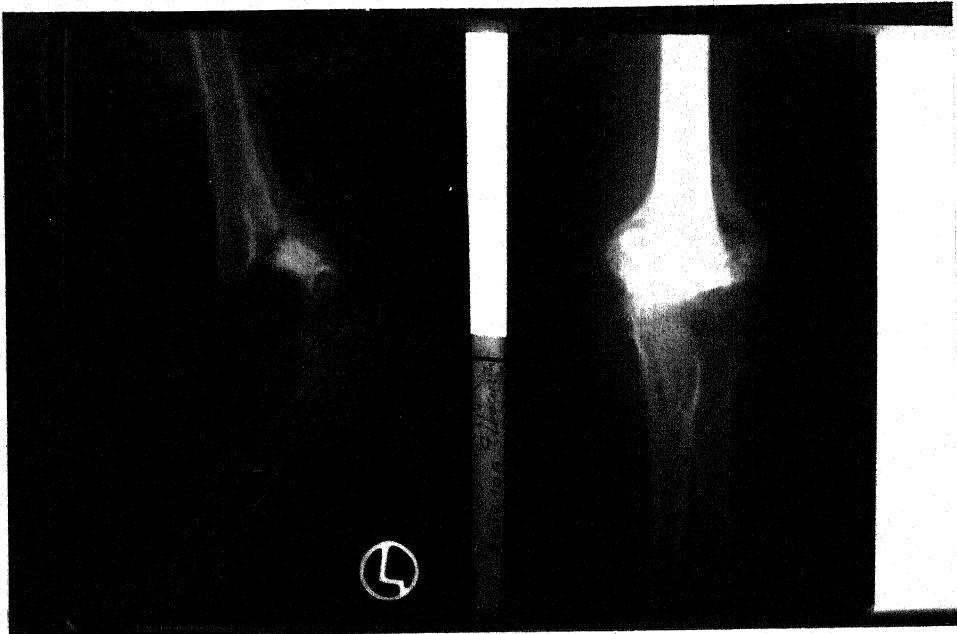
The most common nerve involved is the median nerve specially its anterior interosseous branch; the next most frequent is the radial nerve injury, followed by

ulnar nerve injury.

The incidence of median nerve involvement is approximately 50% in cases with nerve deficit though various studies quote an incidence of 52%⁷, 25%⁴ and 3.0%⁶ of the nerve deficit.^{48,11,39}

David, P. Devito¹⁷ studied the incidence of isolated anterior interosseous nerve injury in supracondylar fractures of humerus in children and out of 15 patients with neurological lesions found anterior interosseous to be involved in six as an isolated injury and in four, in combination with another nerve injury, thus producing a sensory deficit in the latter cases. Two had a complete median nerve palsy. Only three of the fifteen patients had a neurological lesion that did not involve the anterior interosseous nerve; thus they concluded that though the over all incidence of neurological deficits (15%) was similar to other studies the incidence of anterior interosseous nerve lesion particularly an and isolated lesion was much higher and probably the reason for the overlooking of neurological injuries in supracondylar fractures of humerus in children (as it was only a motor deficit).

Dormans P et al²⁰ found 7 cases of isolated anterior interosseous nerve injury out of the total of 19 cases with nerve deficit in their study, in two cases the diagnosis was made in a delayed fashion.



Photograph 1 (above) : The patient (not part of the series) presented one month after injury. The fracture, a type III (Holmberg) posterior has united. The medial spike of the proximal fragment abuts anteriorly.

Photograph 2 (left) : Same patient. Note the pointing index and trophic ulcer present on the tip of index finger.

The most common mechanism of injury of the median nerve and its anterior interosseous branch is by the lateral spike of the proximal fragment in a posterolaterally displaced supracondylar fractures of humerus in children⁴⁸. In a study by Campbell C.C. et al¹² it was associated in this way in 87% of the cases.

In cases of median n.palsy one should be cautious to look for signs of vascular insufficiency with impending VIC as it may be masked by the neurological deficit.⁴⁸

The frequency of radial nerve palsy in cases of supracondylar fractures of humerus in children presenting with neurological deficit has been quoted variously as 25%⁴⁸, 28%¹² and 33%¹¹.

Cambell C.C.¹² et al found all cases of traumatic radial nerve palsy in supracondylar fractures of humerus in children to be associated with posterolateral displacement of a type III/IV supracondylar fractures of humerus in children. The nerve may be injured by an anterior spike of proximal fregment. usually the injury is associated with completely displaced (posterolateral) supracondylar fractures of humerus in children but according to a case report by Sairyo K et al a child with complete severence of the radial nerve was found to have a minimally displaced supracondylar fractures of humerus as seen on radiographs⁴¹.

Most nerve palsies resulting from supracondylar fractures of humerus in children

are neuropraxias and therefore will resolve spontaneously,⁴⁸ . within approximately 16 weeks. However a median nerve palsy associated with vascular insufficiency suggests that these neurovascular structures are entrapped in the fracture site;⁵⁰ motor function should recover by 12 weeks and sensory changes by 24 weeks.

In their study of 200 patients Dormans J.P et al found a return of function in all patients 6 to 16 weeks post injury without any surgical intervention²⁰ . Brown I.C. and Zinar D.N. found similar recovery periods in their study ⁴ . However in the study by Cramer K.E. et al 66% of pts with neurological injuries required open reduction for definitive treatment¹⁷.

Most studies indicate watchful expectancy for as long as 16 -20 weeks following injury and only then should exploration be performed. Jones E.T., Louis D.S. suggest special exercises as well as supportive care to be started as soon as the fracture is healed ²⁹ .

In their case report of isolated radial n. injury Sairyo K et al found complete return of nerve function five weeks after suture of the severed ends, even though the time elapsed since injury was twelve weeks complete function returned!⁴¹

Culp Randal W. et al ³⁹ found spontaneous recovery of nerve function in nine

of the eighteen neural lesions at ten weeks, the remaining underwent neurolysis after 7.5 months of watchful expectancy and all cases had functional recovery after an average follow up of 25 months by return of motion, grip strength and sensibility testing, thus they claim that neurolysis can be a rewarding procedure for neural lesions associated with supracondylar fractures of humerus in children that do not recover spontaneously.

The prognosis of nerve injuries associated with supracondylar fractures of humerus in children is thus excellent the motor function should in most cases recover by three weeks and sensory recovery should occur by 24 weeks.⁴⁸ an isolated motor loss without sensory loss may have a better prognosis.⁴⁸

Ulnar nerve injury unlike the median and radial nerve are often iatrogenic (though they may be traumatic) either due to entrapment at the site behind the medial epicondyle following closed reduction or by the pin itself in percutaneous pinning. Various measures have been advocated for its prevention viz. only lateral fixation if swelling is gross and bony landmarks can not be palpated, localization of the nerve by stimulation with a needle and then anteriorly placing the pins thus avoiding the nerve.

In Ikram's²⁶ series 4 patients. who developed iatrogenic ulnar nerve palsy

following percutaneous pin fixation by K wire in one patient the recovery was complete and immediate when the wire was removed within 48 hrs. of detection. in the other three an exploration had to be undertaken at 6 weeks after removal of K wires when the nerve was found to be trapped behind to medial epicondyle; release and subsequent transposition resulted in recovery.

(ii) Vascular injuries :

Vascular compromise occurs in about 5% of children with supracondylar fractures of humerus in children, however acute compartment syndrome with its sequelae of V.I.C occurs in less than 1%. Fractures with posterolateral displacement of distal fragment are more susceptible to vascular injuries since the medial spike of the proximal humerus can tether the brachial artery.⁴⁸

On exploration of the anticubital fossa of 7 patients with SCFH with vascular insufficiency Schoeneker P.L. et al found that in 3 patients the artery was directly damaged or transected while in the other 4 it was kinked or trapped at the fracture site.⁴²

In the event of a pulseless extremity, prompt reduction of the fracture usually restores palpable arterial flow. In cases where circulation is restored but somewhat diminished when compared to the other side watchful expectancy may be indicated. Complete vascular insufficiency is uncommon because the thick muscle envelope protects the artery. In their exploration of anticubital fossa in 4

cases for non restoration of pulse following reduction Kasser et al found an intimal tear in three and an arterial entrapment in one.²⁷

Vascular evaluation requires differentiation of a pulseless but viable extremity from one with true vascular insufficiency; the collateral circulation is vast and often provides enough distal perfusion despite brachial artery disruption. In a study of 410 with supracondylar fractures of humerus in children Sabharwal et al found a 3.2% incidence (13 cases) of absent radial pulse.⁴⁰ Continuous pulse oximetry has been considered a useful adjunctive for objective follow up of the patients by nurses.⁴⁸ Brachial artery disruption can be reliably determined by obtaining differential Doppler pulse pressures in the hand. Other techniques for detecting patency of the brachial are segmental pressure monitoring, color flow duplex scanning and MRA, which are all non invasive and safe.⁴⁰

For persistent true vascular insufficiency (e.g. an avascular hand) specially if there is associated nerve palsy or inadequate reduction an open anterior reduction is recommended. In such cases the neurovascular structures are often found kinked at the fracture site and liberation restores the pulse. The fasciotomy decreases the incidence of compartment syndrome induced V I C. One should more cautiously search for compartment syndrome in cases with median nerve palsy which may mask the pain of impending acute compartment syndrome.⁴⁸ An arteriogram is

not necessary for confirmation of non functioning of brachial artery and only helps in delaying the immediate treatment, morbidity of surgical exposure is low and procrastination only increases morbidity.³⁴

The decision to perform vascular reconstruction if the vessel does not respond to local measures (eg. adventitia stripping local lidocaine papaverine) is less clear though repair of the damaged brachial artery with saphenous vein has been performed with good results in some studies.⁴²

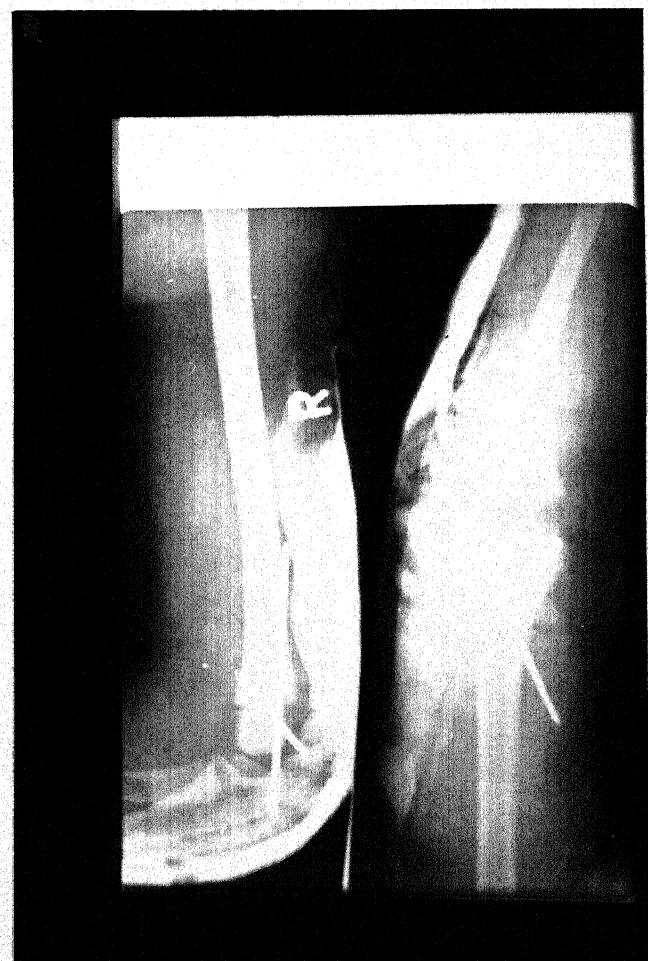
Reconstruction is unnecessary if the distal extremity is well perfused in which case the grafted vessel may not even remain patent.⁴⁰

In their study of thirteen (3.2%) patients (of the four hundred and ten with supracondylar fractures of humerus in children) presenting with an absent radial pulse Sabharwal et al found segmental pressure monitoring, colorflow duplex scanning and magnetic resonance imaging valid, non invasive and, safe techniques in evaluating the patency of the brachial artery and collateral circulation across the elbow. They found that the early revascularization of a pulseless but otherwise viable hand in children with type III supracondylar fractures of humerus in children though feasible and safe has a high rate of asymptomatic reocclusion and residual stenosis of the brachial artery. Therefore a period of close observation with frequent neurovascular checks should be done before more invasive correction of this problem is contemplated.⁴⁰



Photograph 4 (Left) : Case No. 9 presented with compound supracondylar fracture (Rt). The brachial artery was found to be divided at the time of operation and both ends had to be ligated. Note also the floating elbow.

Photograph 5 (below) : Same patient. After two attempts at closed reduction operative intervention had to be adopted. Note persistent rotation (fish tail sign) despite reduction under vision and internal fixation.



There is no clear evidence of a clinical problem with cold intolerance or exercise - induced muscle fatigue for the hand surviving on collateral vascularity but long term studies addressing this problem are lacking.⁵⁰

The floating elbow:

Ipsilateral supracondylar fractures of humerus and fore arm bones in children has been described in literature often referred to as the floating elbow.⁴⁶

In a large study conducted over a period of eight years comprising of thirty four patients with the floating elbow Biyani A et al found that nineteen patients had a fracture of distal quarter of the fore arm bones while eight had a distal radial epiphyseal injury. Five of the patients had an undisplaced supracondylar fractures of humerus in children. All fore arm fractures were treated by closed reduction. Nine of the displaced supracondylar fractures of humerus in children could not be reduced by closed manipulation and were treated by olecranon pin traction in two cases and by percutaneous pinning in seven cases. Excellent or good results were found in twenty nine children after an average follow up of 3.8 years.⁷

According to Williamson DM and Cole WG⁴⁹ displaced supracondylar fractures of humerus in children with fractures of distal fore arm bones are best treated closed reduction and percutaneous pin fixation of the humeral fracture and a below elbow plaster backslab for immobilization of the fore arm fractures. In their study 10 of the 11 patients had excellent results following this treatment policy while



Photograph 3 (above): Results of a mal - united supracondylar fracture (Rt). The patient (not part of the series) suffered injury 8 years back when a POP slab was applied in supination after reduction. No post reduction x-rays were taken. The patient now present with the typical deformity. Movements however were preserved.

	Rt.	Lt.
Extension	184°	186°
Flexion	132°	134°
Carrying angle	-15°	6°

the result in one case was poor because of development of V.I.C.

The late complication of Supracondylar fracture of the humerus :

These have been enumerated as

- Malunion leading to deformities of
- Limitation of movements
- Pain
- Persistence of acute complications

Malunion leads to

(a) Angulation

Varus

Valgus

Anterior

Posterior

(b) Rotation - usually medial and the

(c) Classic gunstock deformity (ie a combination of medial rotation and varus)

The Deformities (The pronated fore arm at the time of injury causing displacement : -

The displacement of the distal fragment may be minimal but more commonly there is substantial complex displacement.⁶ This consists of the following elements

- (I) - Backward shift of the distal fragment.
- (II) Backward angulation of the distal fragment

(III) Pronation of the distal fragment (because the hand is usually pronated at the time of injury). Pronation produces internal rotation of the distal fragment (the two movements are really the same). As a consequence the medial cortex of the distal fragment shifts posteriorly relative to the medial cortex of the shaft of the humerus whilst on the lateral side of the fracture the fragments often remain " hitched " to each other. the pull of the arm muscles then draws the medial side of the distal fragment proximally, posterior to the shaft of the humerus whilst leaving the lateral side roughly in its original anatomical position, the effect of this displacement is to adduct the distal fragment relative to shaft of the humerus, thus pronation results in internal rotation and adduction of the distal fragment.⁶

Various Components of the Deformity:-

The varus / valgus deformity :- change in the carrying angle , is the most common complication which one has to deal with in the treatment of supracondylar fracture of the humerus. It is not only the most common but until recently the most neglected complication.¹² Various studies have been published in which the incidence of carrying angle change after supracondylar fracture of the humerus has been as high 57% and the average in most groups has been approximately 30%.⁴⁵

By definition 1° of carrying angle change at the elbow may be treated as a deformity. Obviously changes which are so minor as to be apparent only to

examination by an experienced surgeon are not of critical importance. Only a change which is of sufficient degree to be noted by the associates of the patient is excessive and should be avoided.

The carrying angle formed by the long axis of the humerus and ulna is subject to considerable individual variation as was emphasized by Aebi in a detailed study of its rotation to age and sex². His measurements of 100 subjects showed values considerably less than those usually quoted. The values in men averaged 6.5° with a range from 0° - 14°; in women the average was 13° with a range from 4° - 20°. The difference in the carrying angles in the two sexes did not appear until puberty.

In a study of 150 normal children comprising eighty girls and seventy boys, aged three to eleven years (the age when S/C are most common) Lyman Smith found the average carrying angle to be 6.1° in the girls with a range of 0° - 12° and 5.4* in boys, with range of 0° - 11°.⁴⁵ These angles were determined by measuring the angle formed by lines joining the midpoint of the wrist and the midpoint of the humeral head as located by palpation, with the midpoint of the antecubital fossa with the elbow fully extended and the forearm in supination. It is of particular interest that 9% of these children had a cubitus rectus or no carrying angle and 48% had a carrying angle of 5° or less. If a child with such a slight carrying angle sustains supracondylar fracture and the fragments heal with disalignement of only a few degrees an obvious varus may be the result. A similar loss in a child

who started with 10° of valgus whould not be noticeable; the final apperance depends on the starting point.

Growth Disturbance as a cause of changes in carrying angles :-

Growth disturbance is frequently blamed as a cause of change in the carrying angle. Brewster and Karp examined eighty cases of cubitus varus deformity and found that clinical measurement of the length of the outside of the arm exceeded those of the inside by one quarter to three quarters of an inch in six.¹⁰ They concluded that this had been caused by stimulation of the external epicondylar and capitellar epiphysis.⁴⁵ This explanation appears most unlikely as it has been demonstrated in the study by Smith that simple medial tilt of the distal fragment gives the same appearance. Furthermore it is difficult to explain the deformity on the basis of a pure growth disturbance in view of the over whelming predominance (ten or more to one) of varus deformities; why should growth of the medial half of the distal epiphysis of the humerus be arrested so much more frequently than that of the lateral half, when the fracture is commonly equidistant from both or conversely why should the fracture stimulate growth of the capitellum so much more frequently than that of the trochlea? Although the roentgenograms of a healed fracture with cubitus varus, commonly show irregular ossification of the trochlea, these changes may well be the result of disalignment and disturbed joint mechanics rather than growth disturbance. Only if the deformity increases with growth can it be attributed

with certainty to growth disturbance.

In an analysis of 292 fractures, Siris found the cartilage plate to be involved in only 21 and of these only 12 showed a growth disturbance, the conclusion seems warranted that growth disturbance is a rare complication and seldom is the cause of a change in the carrying angle.^{13,44}

Various Displacements of the Fragments and their effect on the Carrying Angle :-

To determine the effect on the carrying angle caused by various type of displacements of the distal fragment, an experiment was carried out using an articulated right upper extremity.⁴⁵ A transverse supracondylar fracture was simulated by an osteotomy through the supracondylar region, the fragments being held together by a steel springs. The distal fragment was displaced in various ways and the influence of each position on the carrying angle was determined. It is apparent that only medial or lateral tilt of the distal fragment changes the carrying angle. However other displacement may lead to or contribute to tilting under certain circumstances.

- (i) With an oblique fracture and smooth surfaces under compression as would occur with normal muscle and the elasticity of surrounding soft tissues any rotation about the longitudinal axis of the humerus will inevitably produce tilting; rotation of this type can readily occur in a long arm cast with the elbow in any degree of flexion. The greater the degree of obliquity of the

fracture, the more will be tilt produced by a given amount of rotation.

In transverse Supracondylar fractures the so called transcondylar (diacondylar) fractures the fracture surfaces are very narrow in the anteroposterior direction. In these fractures the bearing surfaces are small and minimum amount of rotations combined with compression forces inevitably cause tilting.

If there is medial or lateral displacement in the presence of compression forces the fracture will be unstable and tilting of the distal fragment will occur, the amount being directly proportional to the amount of displacement. However if there was no end to end contact, the tendency for tilting would be low.

From the experiment it was clear that medial or lateral displacement of distal fragment and rotation of the distal fragment do not in themselves causes carrying angle changes.

Various modalities of treatment for displaced supracondylar fractures as well as various works on them find their source to this troublesome varus deformity. Closed reduction and immobilization by collar and cuff in acute flexion has got a long history with its strong supporters mainly in the veterans such as Sir Astely Cooper (1826), Sir Robert Jones (1921), Watson Jones (1952 - 55) and Charnley (1961) and it is widely accepted as an ideal treatment of supracondylar fractures whether fresh or old.^{16,30,47,15}

Watson Jones (1952 - 55) advised immobilization in 110° -120° of flexion by collar and cuff for 3 weeks under the shirt and 3 weeks over the shirt he claimed excellent results with this mode of treatment.⁴⁷

Later plaster of paris was used for immobilization of the limb which was kept supine and in acute hyperflexion .

The closed reduction with immobilization was criticized on the grounds that it led to severe varus deformity. Lyman Smith deprecated the method stating that " when Waston Jones stated " The prognosis of supracondylar fractures is excellent " he must have been speaking of restoration of function not of form.⁴⁵

In search for a solution to the avoidance of cubits varus / valgus deformity the roll of traction in the treatment of supracondylar fractures was first described by Dunlop in 1939. He gave a straight lateral traction initially and to his surprise the fragments were in perfect apposition, however A.P. angulation remained a problem. Later he started giving a vertical counter traction on the distal arm with traction in a semiflexed elbow.²¹

Dunlop's method was found inconvenient for it needed a watch on the carrying angle and the need to take check x-rays which were fallible, though Allen and Gramse (1945), Dodge (1972), Jefferis (1977) and Alberger (1992) found it to be a useful method. Watson Jones (1952-55) suggested that traction be given for 3-

5 days for the swelling to subside and this be followed by reduction under G.A. with immobilization in full flexion. James Piggot et al (1986) reported comparatively better results if three weeks of traction was immediately followed by active exercises under supervision.³⁸

Traction has been divided into two groups :

(i) Skin Traction : (a) In flexion - Dunlop (1939)²¹
(b) In extension - E.L. Sharkawi and Fatten (1965)⁴³ who used POP cast with traction, Bosanquet and Middleton (1983)⁹ who used the Thomas splint for the purpose and Jefferis (1976)²⁸ who used the straight lateral traction.

(ii) Skeletal Traction :-

Used only with the elbow flexed was first developed by Smith⁴⁵ where a K wire was passed through the olecranon. he used the three bony prominences behind the flexed elbow to guide in the reduction and described it as the visual method of observing for deformity without using the x-rays which he felt were not dependable and were inconvenient.

In the year 1978 Palmer et al³⁷ at Birmingham in order to over come the problem of late varus deformity developed an overhead skeletal traction by means of winged traction screws and felt that the different holes provided a range of directions for applying traction and thus a better control over the deforming forces.

Later in 1984 Worlock and Colton used threaded pin which they claimed unlike Smith 's wire stayed put in its position and thus did not change direction of soruce and reduced pintract infection.⁵¹

Though none of these tractions claimed and accurate reduction the alignment, length and carrying angle was well controlled undervision and by AP x-rays. During the period of skin traction treatment deformity could be corrected from time to time . In sketetal atl traction in flexed position one did not get these advantages and the disadvantages of pintract infection and damage to ulnar nerve were added.

The traction method was criticized on the grounds that it prolonged the duration of stay at hospital and that it was impossible to keep the fidgety child still in bed even for a day leave alone weeks, though Lyman Smith claimed that use of chest restraints was an aqequate means of harnessing the child.⁴⁵

Open reduction and internal fixation was advised by various workers as a means of preventing the deformity by getting accurate reduction and maintaining it by internal fixation. However Watson Jones (1952 - 55) not only discouraged but condemned the procedure on the grounds that

- (i) It is a difficult procedure.
- (ii) It does not provide any added advantage but there are disadvantages like
 - (a) Pintract infection

- (b) Myositis ossificans
- (c) Stiffness of the joint due to capsular fibrosis

Canale (1987) proposed that the incidence of myositis ossificans can be reduced by operating within 5 days of injury.¹⁴

Developed by a Polish surgeon Sokolowski in 1937 closed reduction with percutaneous pinning to fix the fractures site is the most commonly used methods in the more sophisticated centres. Many reports claim much lower incidences of deformity by this method. Proponents of this technique claim that closed reduction and casting without fixation have the highest incidence of residual deformity usually cubitus varus. It is also claimed that no cases of forearm compartment syndrome (i/e ischemic) contrarature have been identified in the cases treated with early pinning compared with casting which they claim is probably because the elbow does not have to be positioned above 90° of flexion to hold the reduction if the fracture has been pinned. The method is also considered advantageous to traction as it reduces the duration of hospitalization. Later displacement of the reduced fragment as occurs in the casting method does not occur thus the carrying angle is maintained.

The disadvantages of the method quoted by the adversaries to this modality are that

- (i) The method is demanding in technique and armamentarium because it is best done under bi planar image intensifirer.

- (ii) Pintract infection
- (iii) Nerve injury specially to the ulnar nerve by the medial pin
- (iv) The technique relies heavily on the roegenograms which however is not infallible

The Fallibility of the Roegenograms :-

In a study of 100 supracondylar fractures of the humerus radiographs were used in an attempt to forecast the result in each case in terms of the final carrying angle. unexpectedly it was found that the forecasts were wrong in well over 50% of the cases . A review of the literature showed similar inconsistencies. The apparent alignment of the fragments shown in the AP radiographs frequently was not consistent with the final carrying angle results recorded for the cases reported.³⁴

The reasons for these discrepancies were contibuted to :

- (i) Superimposition of the radius and ulna in the AP view which can only be avoided by extending the elbow and losing the reduction.
- (ii) Poor visualization of the small distal fragment which is largely cartilagenous int the younger age goups and
- (iii) The influence of the position of the arm when the roegenograms are made on the amount of the angle visualized.

Klienfelter stated that 'angles are projected in correct size only if their axes are parallel to the plain of the film and perpendicular to the central roentgen ray.³²

Thus, if there is any error in the exact positioning of the extremity and the exact placement of the x-ray tube and the cassette any projected angulation will be inaccurate.

Yet this task is relegated to the x-ray technician who is faced with the heroic problem of the exact positioning of swollen elbow in the correct position. If the technician misses the positoning by a few degrees one way or the other, this can not be determined is the roentgenograms and the result will change. Only if the roentgenograms show perfect apposition of the fracture surfaces in all views is there certainty of restoration of the carrying angle.

As has been curtly stated in Campbell (8th edⁿ) the three most common reasons for residual varus or valgus deformity are :¹³

- (i) Inability to interpret poor roentgenograms and thus acceptance of less than adequate reduction.
- (ii) The inability to interperet good roentgenograms because of a lack of knowledge of the pathophysiology of this fracture and
- (iii) The loss of reduction.

Revival of the Pop Cast:-

In the past the hyper flexed elbow was placed in an above elbow POP cast in supination, and it led to a high frequency of angulation.

The prone position of the fore arm has recently been gaining popularity in the relatively recent past.

Arnold JA, Nasca RJ and Nelson CL(1977) in their retrospective survey of eighty two children with Supracondylar fractures of the humerus found forty to have sufficient clinical and roentgenographic data to classify the fractures as varus or valgus and to determine the carrying angles at end results.⁵ The initial displacement (varus or valgus) of the distal fragment correlated with the final carrying angle, but the use of internal fixation, the adequacy of reduction achieved and the duration of traction or immobilization did not. The sixteen varus supracondylar fractures immobilized with the fore arm in supination had a mean varus deformity of about 16° where as the eight immobilized in pronation had a varus deformity of only 3°. The findings in the few valgus fractures suggested that the valgus angulation was less follow up if they had been immobilized in supination. Dissection of eight cadaver limbs and electromyographic studies of one normal limb suggested that the position of the fore arm affects the results by altering muscle tension.

This finding is further supported by the views and experiments of Khare et al in their report based on cadaveric experiments, peroperative observation and clinical study an exact mechanism was described by which full pronation of the forearm prevented cubitus varus deformity in supracondylar fractures of humerus.³¹ They

signified the position of the upper limbs in relation to the chest and demonstrated that even the posterolaterally displaced fractures are better reduced and maintained in pronation.

According to D'Ambrosia RD(1972)¹⁸ the pronation of the fore arm tightened up the lateral and capsule and prevented varus tilt, however as most supracondylar fracture occur proximal to the capsular and ligamentous attachment this explanation is unlikely and displacement is probably controlled by releasing the tension of the flexion pronator muscle group as described by Arnold JA and supported by Khare GN.

OTHER DEFORMITIES:-

The rotational deformity (Most commonly medial rotation) though also not corrected by growth does not cause so much cosmetic abnormality. The external rotation of the shoulder compensates adequately for the rotation, though a higher incidence of osteoarthritis of the shoulder as a result there from claimed by some workers. The facts that one does a wedge osteotomy for significant persistent deformity and never a derotation osteotomy amply proves the point.

Extension of the elbow joint is limited by the olecranon process locking in the olecranon fossa of the humerus if the supracondylar fractures unite with the lower

Results following supracondylar fracture

Results following supracondylar fracture may be graded according to the criteria of Mitchell and adams:

Supracondylar fracture outcome		
Grade	Degrees change from pre-injury	
	Carrying Angle	Range of Motion
Excellent	less than 5	less than 10
Good	5-15	10-20
Unacceptable	more than 15	greater than 20

or the criteria of Henrickson:

Supracondylar fracture outcome			
Criterion	Excellent	Good	Poor
Change in carrying angle	+ / - 10	+ / - 20	+ / - over 25
Limited E/F, P/S	0 - 10	15 - 20	over 25
Pain	None	On exertion or weather change	On exertion or weather change
Symptoms at work	None	Mild	Severe
Muscle contracture	None	None	Yes
Persistent nerve injury	No	No	Yes

fragment of the humerus carrying the olecranon fossa, tilted forwards 30° this locking occurs 30° before the normal limits of extension is reached.

Similarly uncorrected backward tilting of the lower fragment causes permanent limitation of flexion.

Other causes of limitation of movement are :

- (i) Myositis ossificans
- (ii) Capsular Fibrosis

The pronation supination movements are usually well preserved.

Evaluation of results :- It may be said that the evaluation of results following supracondylar fractures is an evaluation of the residual scars left by the injury in terms of deformity dys / functuion etc.

In Mitchell and Adam's criteria³⁵ the fractures are graded as excellent good or unacceptable only on the basis of degrees of change from pre injury in the carrying angle and range of motion.

According to Henrickson's criteria ²⁴again the results are classified into excellent, good and poor based on :

- (i) Change in carrying angle
- (ii) Limited E/F,P/S
- (iii) Pain
- (iv) Symptoms at work
- (v) Muscle contracture
- (vi) Persistent nerve injury

MATERIAL & METHODS

Material & Methods

The study was conducted in the department of orthopaedics M.L.B.Medical College,Jhansi . Patients included twenty one children admitted after presenting at the O.P.D. or emergency with displaced (Type II & Type III Gartland) fractures of the supracondylar area of the humerus.

The patients were admitted after making the clinical diagnosis and confirming it by roentgenographic examination of the elbow in AP and lat views, The patients were given an above elbow slab in position of the presentation of the limb and the limbs elevated while the patients waited for the reduction of the fracture under general anaesthesia .

The fracture was reduced in the emergency operation theatre and an above elbow slab was applied with the elbow hyperflexed and the forearm in supination / pronation The patients were transferred to the general ward and kept under observation for the next 24 hrs. to rule out any present or developing neurovascular complications.

Post reduction x-rays were assessed for adequacy of reduction and if unsatisfactory, reduction was re-attempted. If the reduction was satisfactory the patients were discharged after application of cast and to report at 3 weeks post reduction for removal of the cast and assessment of clinical union. In cases where open reduction and K wire fixation was done, wires were removed at the first visit (3 weeks after discharge) and the patients reviewed after further 3 weeks for removal of cast. After confirming clinical union the patients were sent home with advice regarding physiotherapy and reviewed thereafter at monthly intervals.

At each visit the patients were evaluated for recovery of function etc.

The Working proforma is this thesis may be divided into four sections viz :

- i) At the time of presentation
- ii) During reduction & stay at hospital (till discharge)
- iii) First & subsequent follow up in OPD
- iv) Final evaluation in OPD

(i) At the time of presentation

Name: MRD No:

Age : Ward/Bed:

Sex : Surgeon Incharge:

Fathers Name: Date of admission:

Address:

Time since injury:

Mode of Injury : (a brief history of the cause of injury)

Side Involved : (Right/Left) elbow

Clinical Impression:

Radiological diagnosis (Grading according to Holmberg and any other specific finding) :

Routine Investigations viz : Blood - Hb%, TLC, DLC, ESR

Urine - Routine
- Microscopic

Acute Complication present :

Vascular :

Neurological:

- a) Median/Anterior Interosseous
- b) Ulnar
- c) Radial

Associated Injuries:

The criteria used for assesment
of these complications were

Vascular : Vascular deficit was said to be present if the radial pulse was not palpable on the injured side.

Neurological : Sensory & motor functions were tested as shown below -

Neurological deficit	Sensory Loss	Motor loss
Median Nerve	Loss of sensation in the lateral 3.5 digits	Loss of function of flexor pollicis longus / flexor digitorum profundus / and specially abductor pollicis brevis.
Ant interosseous Nerve	Absent	either of above
Radial Nerve	Loss of sensation in the area of dorsal skin between 1st & 2nd metacarpal	Presence of wrist drop
Ulnar Nerve	Loss of sensation in the Medial 1.5 digits	Loss of function of interossei / adductor pollicis / flexor carpi ulnaris

Associated Injuries: The criteria used for assessment of these complications are given on next page; Associated injuries as ipsilateral both bone distal forearm as well as any other bony injury were looked for.

(ii) During reduction and stay at hospital (till discharge)

Observations for the following were made and recorded :

Adequacy of reduction (any persisting rotation /displacement)

If inadequate, number of reductions attempted before accepting position

Position of forearm after reduction of the supracondylar fracture and of other fractures if associated with it:

Adequacy of circulation :

Persistence /new development of neurovascular deficits:

Date of discharge:

Duration of hospital stay :

(iii) First Follow up in OPD

Assesment of clinical union after removal of cast (at three weeks in conservative cases and six weeks in operated cases or cases with associated injuries.

Reevaluation of the neurovascular status where required was done in this and the subsequent visits on the criteria given earlier. The patients were advised on physiotherapy and care of limb etc.

(iv) Final Evaluation : After the shiftness had subsided patients were evaluated for the following:

- (a) Pain : Persisting pain at fracture site or in the rest of the limb
- (b) Persistence of neurovascular complications viz

Symptoms at work

Muscle contraction

Persistent neurological deficits

(v) Movements: Left (in degrees) Right (in degrees) Loss in degrees

- a) flexion
- b) extension
- c) pronation
- d) supination

(vi) Carrying angle : Left (in degrees) Right (in degrees) Loss in degrees

The criteria used for these measurements were as follows:

(a) Flexion : With the arm by the side the patient was asked to flex his elbows as much as possible and the angle made between the long axis of arm and forearm was measured on both sides by placing the goniometer on the lateral side of elbow joint.

(b) Extension : With the arm flexed to 90° that is in horizontal position with elbows fully extended and the palms facing the roof the goniometer was placed on the lateral side of elbow joint and the angle made between the long axis of arm and forearm was measured on both sides.

(c & d) Pronation & Supination : With the arm fixed by the side (to prevent rotation at the shoulder the patient was asked to alternately face the palm towards the roof and floor. If the palm could face fully upwards and downwards it was recorded as +. If midway between full range and midprone position it was recorded as +/- and if no movement on either of the sides then as 0.

(v) Carrying Angle : This was measured by the method described by Lyman Smith. With the elbow fully extended as in (b) the angle formed by extending the line from midpoint of wrist and humeral head to join the midpoint of the elbow joint.

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Technique for Reduction :-

With the patient supine on the table general anaesthesia is given; the assistant grasps the upper arm whilst the surgeon holds the hand. The surgeon then applies firm steady traction for a period of two minutes or more in the long axis of forearm until traction has drawn the distal fragment beyond the proximal fragment. Following traction in the flexed position, the surgeon extends the elbow palpating the radial pulse as the does so.

When full extension has been obtained the forearm is fully supinated to correct the pronation deformity present.

The fact that the hand and distal fragment are fully supinated is confirmed by fully supinating the uninjured hand and externally rotating the shoulder ; The two hands should now have assumed the same attitude. Next the carrying angle at the elbow is corrected by eye. The surgeon then grasps the upper arm with his second hand placing his finger over the biceps muscles so that his thumb rest on the olecranon. He then changes the position of the hand exerting traction by placing it so that he grasps the distal forearm with his index on the radial pulse. He then slowly flexes the elbow using the hand with which he is exerting traction to produce a combination of flexion and continuous traction in the long axis of the forearm .

The thumb over the olecranon presses the olecranon (and with its the distal

fragment) forwards into flexion, the fingers of this hand exert counter - traction against the hand pulling in the long axis of the forearm.

Flexion is continued until a point beyond 90° is reached. Throughout this manouevre the radial pulse is felt and if it is obliterated by flexion the elbow is extended until the pulse returns. When the maximum degree of flexion has been obtained compatible with the presence of a radial pulse a light back slab is applied over padding to hold this position and the reduction is checked radiologically.

Post Reduction Management :- After transferring the patients to the ward, the limb was elevated. The patients vitals were recorded and adequacy of hydration estimated and fluids adjusted accordingly. The patient was kept nil per orally for next six hours post - operatively and advised active finger movements of the injured limb. The patients were discharged after completion of the slab and asked to report after 3 weeks in the O.P.D..

OBSERVATIONS

OBSERVATIONS

These observations are based on the 21 cases with supracondylar fractures of the humerus in children that were admitted at M.L.B. Medical College Jhansi between the period mid October' 96 to September '97. However, of the 21 patients, 18 could be followed till completion of the study; the other 3 cases could not be followed and were used only for epidemiological datas. Of the 3 patients 2 absconded from treatment while the 3rd was lost on follow up.

After clinicoradiological diagnosis the patients were treated conservatively by reduction of the fracture under general anaesthesia and application of an above elbow POP cast in either supination or pronation with the elbow in hyperflexed position unless, compelling reasons forced abandonment of closed reduction. The patients were followed up in the OPD after discharge at regular intervals.

The results were evaluated on the basis of criteria given earlier (in Material & Methods). The results were tabulated as shown in Appendix I. Following observations were made which have been for convenience divided into epidemiological considerations, acute complications and late complications/deformity . Where possible tables , bar diagrams & pie chart have been added to depict the same .

Epidemiological Considerations :

(i) Seasonal Variations : The bar diagram on the next page shows the seasonal variation of cases of supracondylar fractures of the humerus in children as seen in this

this study . A peak in incidence has been reported in the summer months in various studies.

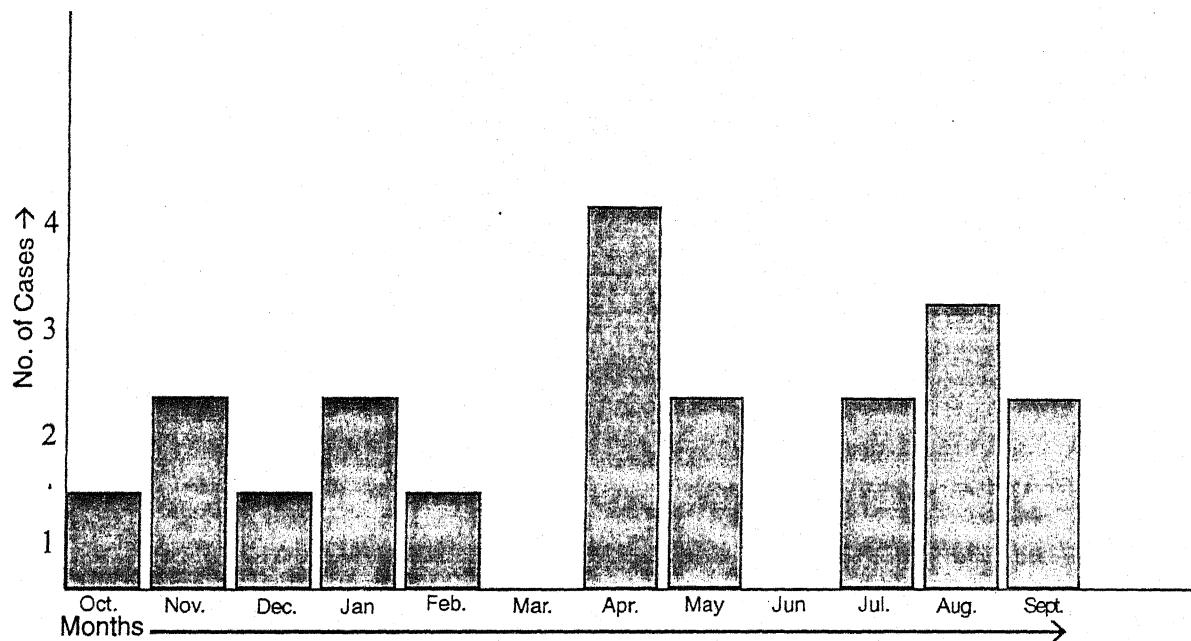


fig .1

Showing the seasonal incidence of supracondylar fracture of humerus in children

However in this study the cases were found to peak in late spring (April) while there were no cases in the months of March & June. A second rise was seen in late monsoon months from July to September.

(ii) Age: The youngest patient in this study was a child of four years while the eldest was thirteen years old. Supracondylar fractures of the humerus have been described in the age group between 3 years & 12 years, with the peak at 7.5 years of age.

In this study the peak age of incidence was at the sixth & eighth year of life. The bar diagram on the next page shows the incidence with respect to age of the patients.

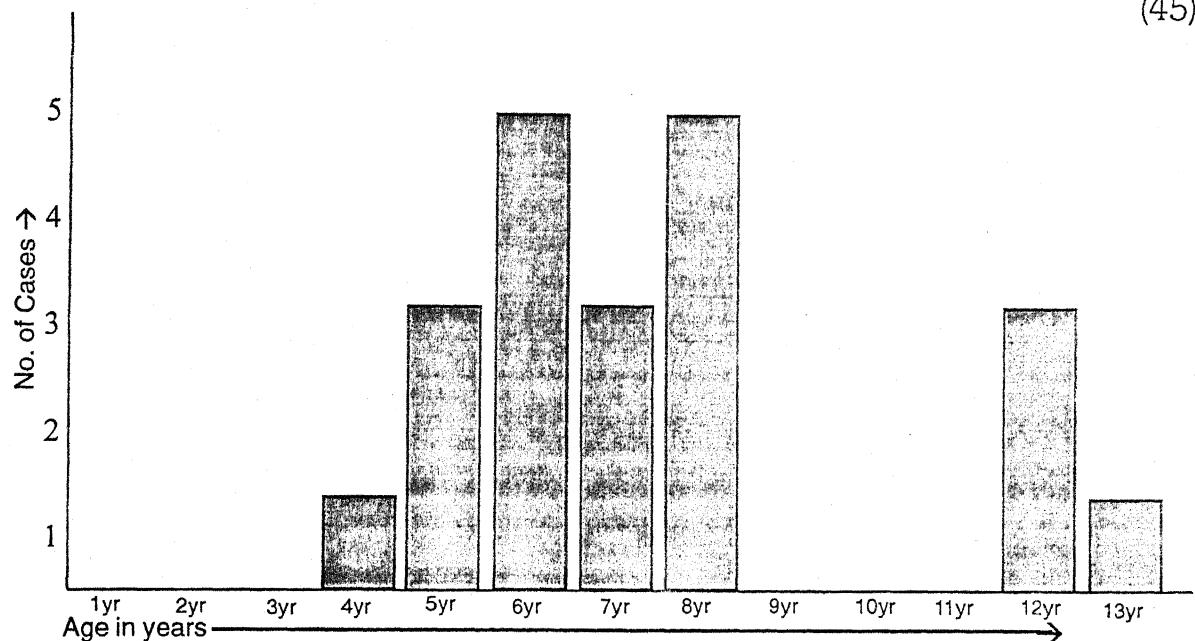


fig .2

Showing the incidence of supracondylar fracture of humerus in children at various ages

(iii) Sex: Males are reported to be more commonly affected than females. In this study of 21 cases 14 patients were male while 7 patients were female, making a ratio of 2 : 1 for male predominance. The table below shows the incidence in both the sexes.

Table 1
showing the ratio of males to females succumbing to supracondylar fracture of the humerus

Sex	No.	%
Males	14	66.6
Females	7	33.3

(iv) Sidedness: Left side has been reported to be more frequently affected than the right side for all age groups and in both sexes. Literature quotes an incidence of 63%.

The table below shows the sidewise distribution of cases as a whole and in either sexes.

Table 2
showing sidedness of the injury in the two sexes

	Left	% (L)	Right	% (R)
Male	10	71.4	4	28.6
Female	5	71.4	2	28.6
Total	15		6	
Total %	71.4			28.6

Thus in the study 71.4 % of the patients had a fracture of the left supracondylar region while 28.6 % had a right sided involvement. Sex wise sidedness also followed queue to a surprising exactness !

(v) Mode of Injury : The most common mode of injury was a fall on the outstretched hand while playing which accounted for 71.4 % (15 out of 21) cases. Thus the trauma was trivial in the majority of cases; the other 6 cases gave a history of fall from height.

Table 3
showing the mode of the injury in various cases in this study

Mode of Injury	No. of Cases		Total (%)
	L (%)	R (%)	
Fall on out stretched hand	11 (73.3)	4 (26.7)	15 (71.4)
Fall from height	4 (66.6)	2 (33.3)	6 (28.6)
Total	15	6	21

The table above shows the individual modes of injury in the left & right sided fractures in the study population.

(vi) Radiological grading of fractures: In this study of supracondylar fractures of humerus in children Holmberg's criteria was used to classify the fractures as types I to IV . The incidence of the various grades has been shown in table 4 & an attempt has been made to correlate the mode of injury with the severity of displacements.

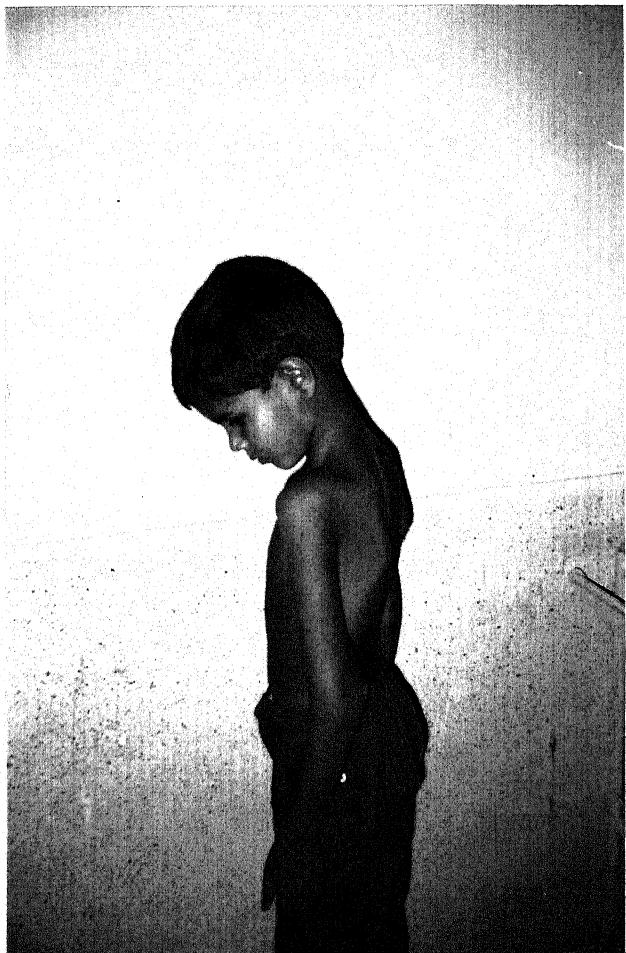
Table 4
showing the relationship between severity and mode of the injury

Grade	No. of cases	%	Mode of injury	
			Trivial trauma	Fall from height
I	1		---	1
II	4		4	---
III	6		4	2
IV	10		7	3

Thus of the displaced fractures, four cases (20 %) were type II , 6 cases (30%) were type III while 50% (10 cases)were type IV injuries. Case No. 16 (the only one with type I injury was admitted for the associated acute complication of the injury rather than for any definitive treatment viz . fracture both bone forearm with blisters on the hand and over the elbow, with impending VIC.

(vii) Compound v/s Simple : The incidence of compounding in supracondylar fractures of the humerus in children is claimed to be around 1%. However, in this small series of patients with this type of injury there was 1 case with compound fractures and this made the incidence rise to 48% .

(viii) Time between injury and seeking of Treatment at hospital : In the Indian situation it is not surprising for the patient to seek definitive treatment after much attempts at



Photograph 6 (Left) and 7 (below) : (Not part of the series). Late presentation is not unusual in supracondylar fractures. The patient presented one month after injury with the fracture malunited and with VIC (see photograph below and also photographs 1 & 2) Note also the medial rotation made obvious by externally rotating the shoulder (below); the anticubital fossa on the left side faces somewhat anteriorly. Note also the other deformities. There was gross restriction of all movements.



'bone - setting' by the quacks and local 'bone - setters', or even at times seek no treatment at all. Thus there is often a delay in treatment.

In this series the time interval between injury and seeking of treatment was on an average 3.2 days with the minimum of 2 hours and a maximum of 15 days. Mode which denotes the central tendency was 6 hours and the median time interval between injury and treatment seeking was also 6 hours.

Acute Complications :

(ix) Other injuries: Other bony injuries that have been found to be directly associated with supracondylar fractures of the humerus in children are ipsilateral fractures of both bones of the forearm in their distal quarter (the floating elbow). In this study there were 3 cases of fractures of both bones of forearm (case No.2,9 & 16) though case No.9 was actually a fracture separation of the distal radial epiphysis while no. 9 had injuries other than that in the ipsilateral limb.

All cases suffered trauma after fall from of height, with the most severe injury in case no. 9 (fall from roof); other unassociated injuries were present in that case. Right side was involved in 67% of the cases and the left side in 33%. Of the total left sided fracture these injuries constituted 6.66% of the cases while of the right sided fracture it was present in 33 % of the cases .

The injuries were not necessarily associated with completely displaced fractures of the supracondylar region as different grades (viz I, III & IV) were found to be associated with these injuries. The table below describes the injuries in detail.

Table 5

showing the relationship between grade of fracture and associated injuries as seen in this study

Case No.	Mode of Injury	Side	Type of fracture	Details of associated injury
2.	Fall from height	L	III	# separation radial epiphysis & # ulna (L.E.)
9.	Fall from height	R	IV	# B.B. forearm (L.E.) & compd. # tibia (Lt.)
16.	Fall from height	R	I	# B.B. forearm Rt. (L.E.)

(x) Neurological Complications: The incidence of neurological complications have been quoted variously as 5% to upto 17%, and may involve the median,ulnar or the radial nerve, at the elbow. In the study the incidence was 19% and involved either the median or its motor branch the anterior interosseous nerve. The table below shows the incidence of the neurological complications as seen in this series :

Table 6

showing the incidence and period of recovery of neurological deficits as seen in this study

Case No.	Neurological deficit			Period of recovery
	Median	Radial	Ulnar	
4.	Median N. palsy	--	--	14 weeks
5.	Ant. Interosseous Nerve palsy	--	--	14 weeks
16.	Ant. Interosseous Nerve palsy	--	--	Not followed
21	Ant. Interosseous Nerve palsy	--	--	16 weeks

All cases were neuropraxias as they recovered completely within 3.5 to 4 months time.

(xi) Vascular Complications : There were five patients presenting with an absent radial pulse, thus making incidence of vascular complication in this series as high as 23.8% . Of the five patients in case no.2 and no. 5 there was immediate return of radial pulse on reduction while in case no.3, it became palpable on the third day of admission. In case no.9 there was complete disruption of the brachial artery and both ends had to be ligated to prevent the bleeding . The limb however re

mained well perfused. Case no. 15 presented with signs of V.I.C. and absent radial pulse . However the patient absconded from treatment and could not be followed . Case no.5 had both neurological and vascular deficits, both of which recovered ; the latter immediately on reduction while the former took 14 weeks to recover.

The table below shows the incidence of vascular complications seen in this series .

Table 7

showing the incidence and period of recovery of vascular deficits as seen in this study

Case No.	Name	Vascular Complications	Period of recovery
2.	Roshan	absent radial pulse	Immediate (on reduction)
3.	Ashim	absent radial pulse	Palpable at discharge
5.	Ashok	absent radial pulse	Immediate (on reduction)
9.	Chandni	Brachial art. disruption	Not followed
15.	Rahul	Impending V.I.C.	Not followed

(xii) No. of reductions attempted : The table below shows the no. of attempts at reduction made before acceptance of position in the various cases in this series.

Table 8

shows the no. of attempts at reduction required in this study in different cases .

No. of attempts at closed reduction	No. of Cases	% of Total No.
1	7	35
2	13	65

In three cases a second closed attempt at reduction also failed to give an acceptable position (case no.5,9 &15) and the method was abonded in favour of operative methods of open reduction and K wire fixation. In case no.16 the patient was admitted with type I fracture only for the management of associated neurovascular complications.

(xiii) Position of the forearm after final attempt at reduction (prone v/s supine): Of the 17 patients treated conservatively the no. of patients treated with final position of forearm in supine position was 9 while in 8 cases it was in the prone position.

Table 9

shows the final position of forearm in cases treated conservatively

Final P.O.P.(posi ⁿ .) (P/S)	No. of Cases	% of Total No.
Pronation	8	
Supination	9	

Of the 8 cases with POP finally applied in prone position 7 cases had initially been given an above elbow POP in supine position. However of the nine cases with final supine position none had initially been in the prone position.

The flowchart below clarifies this:

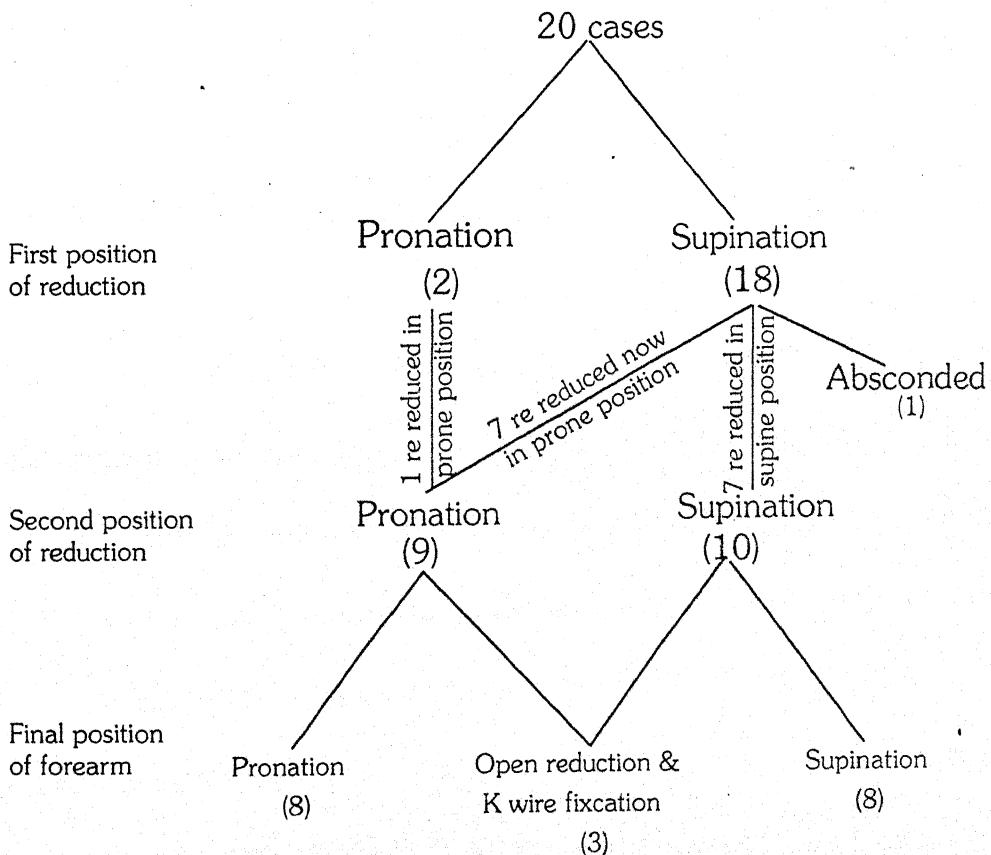


fig .3

shows the various different modalities of treatment in various cases in this study

Thus 12 of the 18 cases with initial POP applied in supination had to be re-reduced while only one with pronation had to be reattempted and was found to be irreducible and thus open reduction was sought. In the supination group one patients absconded living 17 cases of which 7 had to be re-reduced in the prone position, 5 were reapplied with the forearm in supine position and of this 2 needed a further open reduction and K wire fixation.

(xiv) Duration of hospital stay : In this study the minimum duration of hospital stay was one day while the maximum was 32 days .The table below shows the relationship between the number of attempts at reduction and duration of hospital stay.

Table 10

shows the relationship of no. of attempts at reduction and the duration of hospital stay

No. of attempts	Avg. duration.of hospital stay
1	4 days
2	5.8 days
3(operative intervention)	25 days

Thus the no. of attempts related closely with the average duration of hospitalization, and was maximum in cases with operative intervention. However one should consider the distortion caused by the long time spent in attempts at closed reduction before it was resorted to. In patients in whom only one attempt was made the average duration of hospital stay was 4 days, in cases with two attempts it was 5.8 days, while in those with operative intervention it was 25 days.

(xv) Residual Neurovascular Deficits: None of the patients followed had any residual neurovascular deficits. Of the neurovascular deficits case no.4 recovered completely 18 weeks post discharge from hospital while case no.5, recovered by 14 weeks;

cases no. 16 & 21 recovered by 16 weeks each. The average period of recovery was 16 weeks.

Of the vascular deficits in two cases with absent radial pulse (case no. 2 & 5) immediate return of pulse was found on reduction while in one case (case no. 3) it was palpable 3 days after reduction of fracture.

In one case with complete disruption of brachial artery (case no. 9) the limb was well perfused and there were no signs of ischemia.

Case no. 16 with impending VIC and involvement of anterior interosseous nerve absconded and could not be followed.

Final Evaluation: These observations have been further divided into -

- (a) Movements
- (b) Deformity

(xvi) Pronation v/s Supination : According to the criteria used, (see Material & Methods) all patients had complete recovery pronation & supination movements on the injured side i.e. to say all the patients could face the palm towards the roof & floor after immobilizing the shoulder by keeping the elbow flexed to right angle with the arm by the side of the trunk.

Thus there was no restriction of motion as far as pronation & supination was concerned.

(xvii) Extension at the elbow:

- (a) Normal elbow
- (b) Injured elbow

(a) Normal elbow : The range of extension was from 0° i.e. fully extended to -19° (i.e.

hyperextensible) with an average of -3.6° of extension. Thirty nine percent of the cases had 0° extension while Sixty one percent had hyperextension at the elbow joint.

Table 11

(Showing the range of extensibility of elbow in the normal limbs)

Degree of extension	No. of cases
0°	7
Up to $<5^\circ$	7
5° to $<10^\circ$	2
10° to $<20^\circ$	2
Total No. of cases	18

(b) Injured elbow: The range of extension loss was from 0° to up to 20° with an average of 3° loss. Twenty two percent of cases lost $<5^\circ$ of extension, while 10 to 20° loss was seen in 16.6% of the total cases.

Table 12

(Showing the loss of extension of elbow in the injured limbs)

Degree of loss	No. of cases
0° to $<5^\circ$	4
5° to $<10^\circ$	0
10° to 20°	3

(xviii) Flexion at the elbow:

(a) Normal elbow

(b) Injured elbow

(a) Normal elbow : The range of flexion was from 130° to 152° with an average 142° of flexion.

(b) Injured elbow: The range of flexion loss was from none to up to 20° with an average of 4.5° loss. Seventeen percent of cases lost $< 5^\circ$ of flexion while 5 to 10° loss was seen in 16.7% of cases and from 10 to 20° loss in 16% of cases.

Table 13

(Showing the loss of flexion of elbow in the injured limbs)

Degree of loss	No. of cases
0° to $< 5^\circ$	2
5° to $< 10^\circ$	3
10° to 20°	3

(xix) Carrying angle: The range of carrying angle in the various patients of the series was from 0° to 11° . The minimum carrying angle was 0° (cubitus rectus) in 5.6% of the cases and the maximum carrying angle was 11° . The average carrying angle in males was 5.25° while in females it was 7° .

The loss of carrying angle in the injured elbows ranged from 0° to 20° . The table below shows the loss in degrees of carrying angle.

Table 14
(Showing the loss of carrying angle at elbow in the injured limbs)

Degree of loss	No. of cases
0° to $< 5^\circ$	9
5° to $< 10^\circ$	6
10° to 20°	3



Photograph 8 (above) : Case No. 7, treated with forearm in supination. Gross displacement seen is both AP and lat. post reduction views.

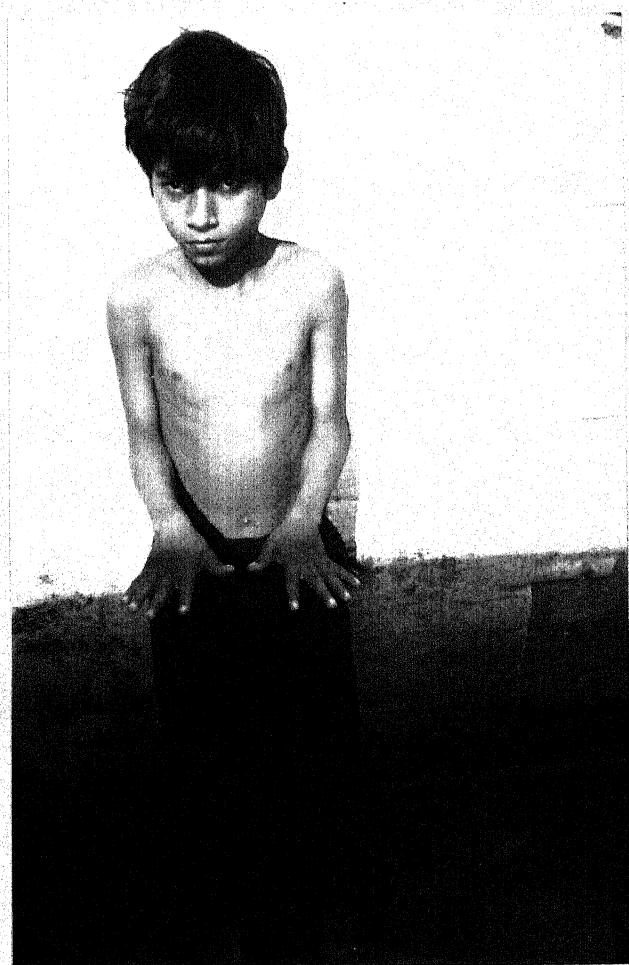
Photograph 9 (below) : Same case. POP again in supination ; though the AP view now shows adequate reduction, rotation is still present as seen in lateral view.





Photograph 10 (Left) and 11 (below) : Same patient as on last page, though there was slight loss of flexion and extension, supination and pronation were not restricted. The final measurements were:

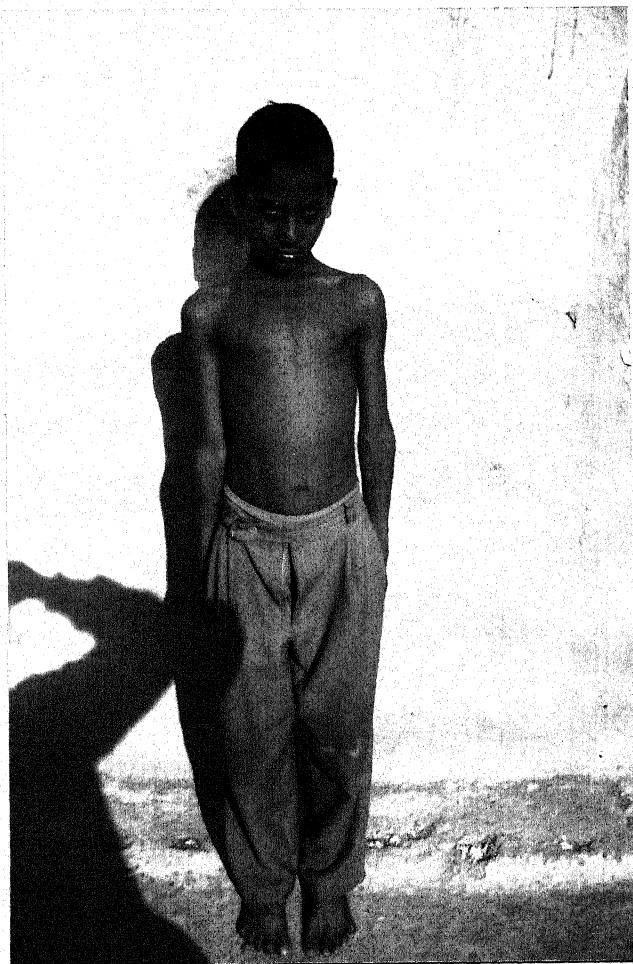
	Rt.	Lt.
Flexion	116°	136°
Extension	-19°	1°
Pronation	Full	Full
Supination	Full	Full
carrying Angle	10°	1°





Photograph 12 (Left) and 13 (below) : Another case treated with forearm in supination (Case No.8). The patient developed a loss of carrying angle of 17° on the injured (lt) side. But see next page !





Photograph 14 : Same patient as on last page : Though there was a loss of carrying angle of 17° the apparent deformity with the limb by the side is minimal. Rotation at the shoulder partly masks the deformity.



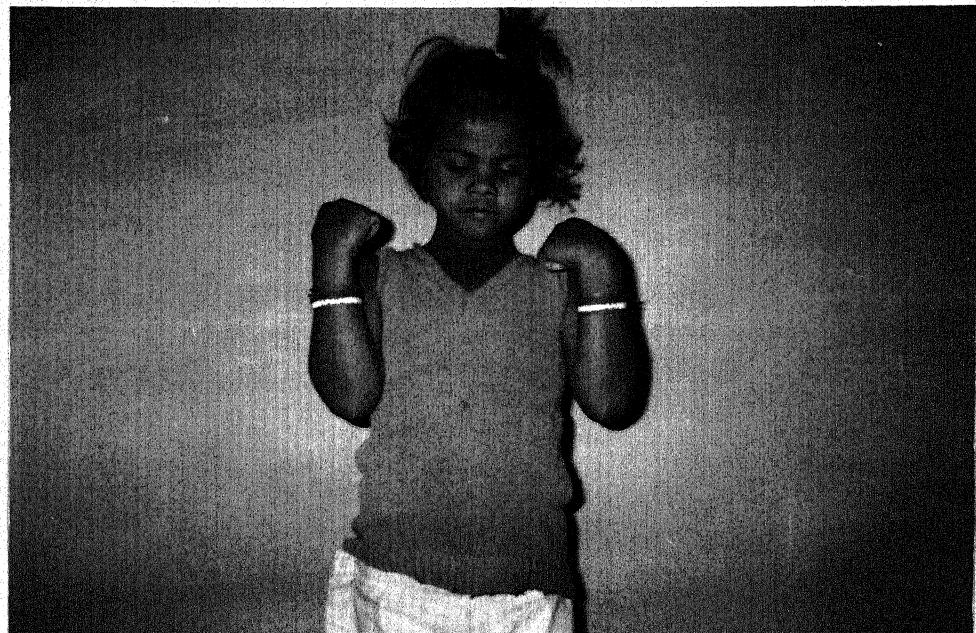
Photograph 15 :(above) : Case No.17, The patient presented five days after injury (see also photograph 24 & 25). The forearm was placed in prone position.

Photograph 16 :(below) :Same case, 8 months post injury. Remodelling is already in progress.





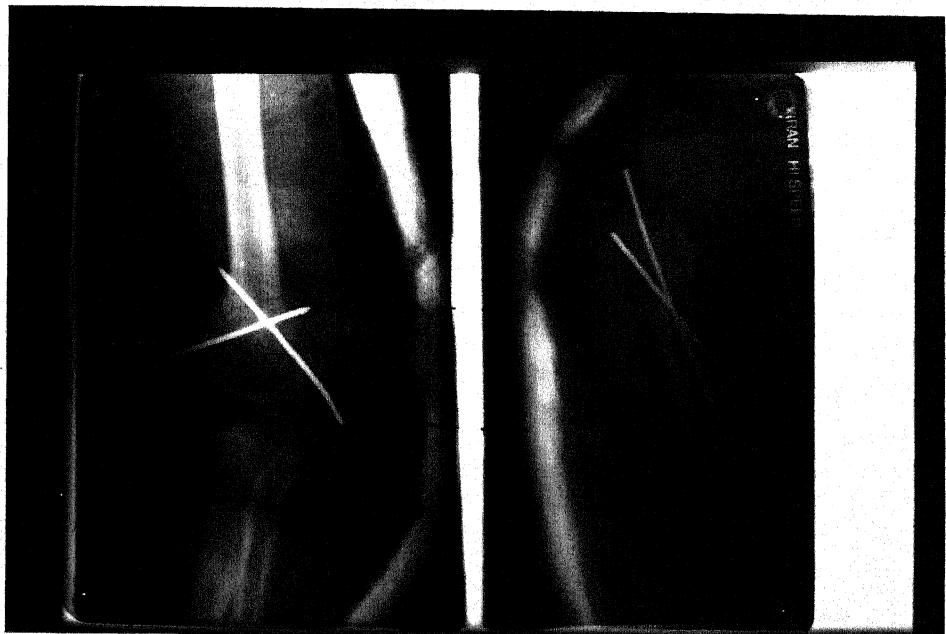
Photograph 17 : (Left) and 18 (below) : Same patient as on last page. The patient had a loss of carrying angle of only 3 degrees even though no comment can be made from the post reduction x-rays (see photograph 15).





Photograph 19 : (Left) and 20 (below): Case No. 18
Another patient treated with the forearm in prone position. There was no measurable loss of carrying angle and even the movements were fully preserved.





Photograph 21 :(above) and 22 (below) : Case No.15. The patient was treated by delayed open reduction and internal fixation. Reduction appears to be adequate. But see below. Note the medial rotation as seen by the medial tilting of the 3 bony prominences on Rt. side (a method described by Lyman Smith). See also next page.

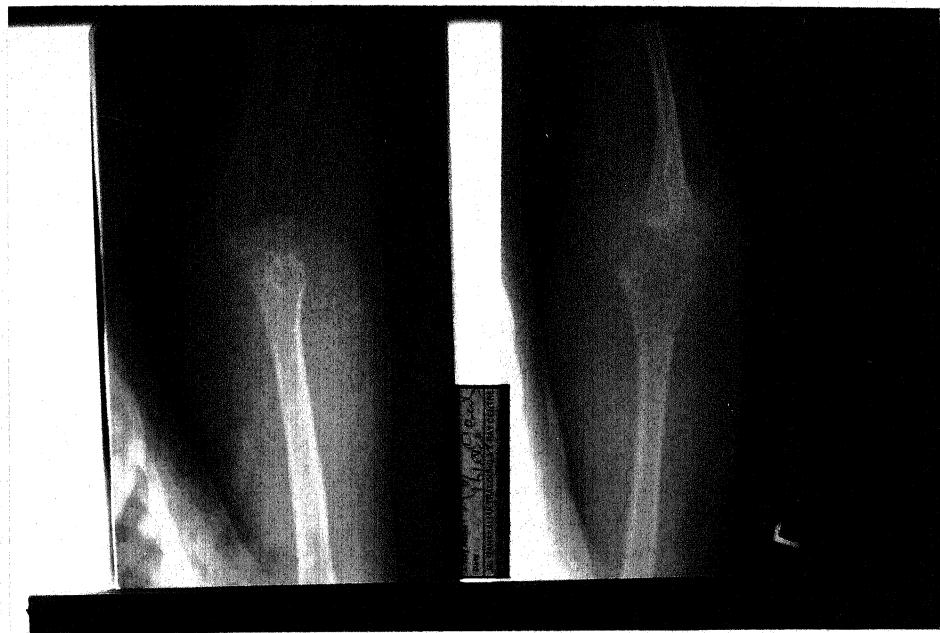




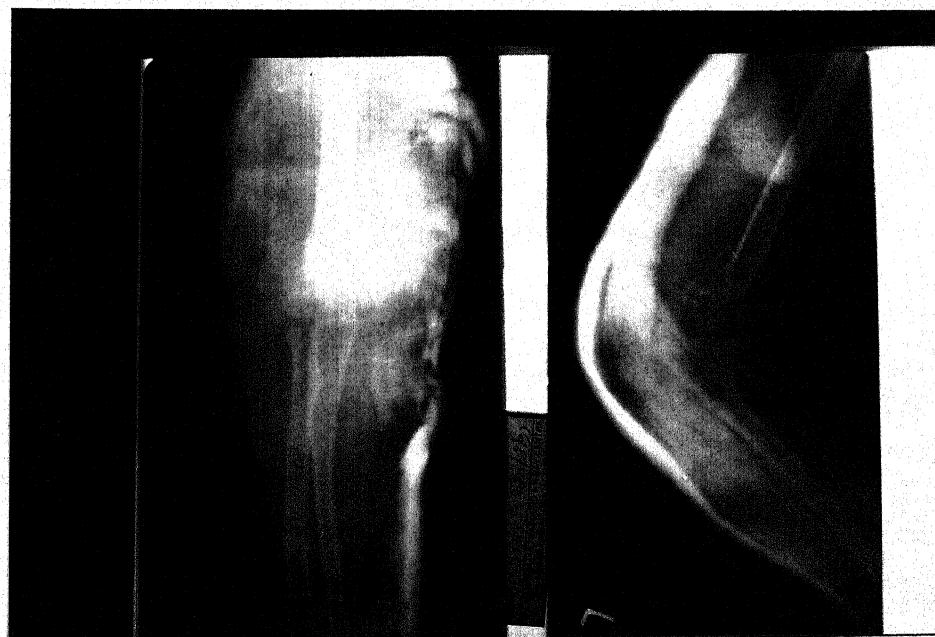
Photograph 23 :Same patient as on last page. Note the obvious loss of carrying angle. The patient had maximum loss of carrying angle in this series.

DISCUSSION

An error in judgement !



Photograph 24 : (above) and 25 (below) : Case no. 17. The patient was misdiagnosed as a case of suspected Type I fracture. A true lateral radiograph 5 days later told a different story (see text).



DISCUSSION

Supracondylar fracture of the humerus in children is the most common and a 'troublesome injury' of the elbow in children, and if not treated adequately, leaves in the wake of its healing a permanent deformity which may range from a mild unobservable one to a severe varus (usually) or valgus (rare & milder) deformity or even a gunstock deformity, in the untreated cases. However 'the functional results are excellent' Watson Jones.

The diagnosis of this injury is easy to make. A child of 3 to 12 years of age presents with a swollen semiflexed elbow (usually) left with the limb in semi prone position supported by the other hand or a sling. A history of trivial trauma classically fall on the out stretched hand is usually elicited. A radiograph of the easily visualises the fracture confirming the diagnosis and classifying the fracture.

But see photograph 24 & 25! The patient (case no. 17), was diagnosed after AP & 'lateral' x-rays as a case of probable undisplaced supracondylar fracture left. and was given an above elbow slab and was to be reviewed in the next OPD. Five days later the patient returned without x-rays or old OPD slip and to verify the diagnosis a re x-ray was done the x-ray now a true lateral view (recognized by the hour glass appearance of the distal metaphysis) showed a posteriorly displace supracondylar fracture of the humerus of grade II. Such is the importance of a true lateral view in the diagnosis and grading of a supracondylar fracture in children. Campbell (8th edition) describes this difficulty of roentgenographic judgement as inability to interpret poor x-rays and thus accept the deformity.

Abraham (1982) claimed that metaphyseal remodelling further weakens the

already weak area in the most susceptible 7.5 year age group. Haris (1978) claimed that the predisposition was due to hyperextensibility at the elbow which stemmed from ligamentous laxity in those succumbing to this injury. Abraham (1982) experimentally demonstrated that if force exerted on the hyperextended elbow it is transmitted to the anterior aspect of the elbow through the olecranon fossa. Thus not much force is required to cause this injury and a trivial trauma in the guise of a fall on the outstretched hand is sufficient.

Thus Wilkins (1991) concluded that 3 predisposing factors made this region the weakest link in the chain.

- (a) Bony architecture of the lower end of humerus in susceptible age group.
- (b) Ligamentous laxity which allows hyperextension.
- (c) Relationship of joint structures in hyperextension due to fall on outstretched hand.

Usually the elbow can be extended up to 0° . In this study group hyperextensibility was present in 61% of cases with some having as high as -16° to -19° of hyperextensibility.

In this study the peak incidence of injury was in the age groups 6 to 8 years with a clustering of cases from 4th to 8th year of life and yet another rise at 12 year age. Study claims a peak 7.5 years. However the central tendency in this study i.e. the mode was 7 years. Could this be because of earlier maturity of children in the tropics with an earlier age of remodelling.

The lever mechanics described by William probably also explain the reason for the injury occurring after trivial trauma in this study. In this series, 71% of cases (15 out

of 21) suffered minimal trauma, while in 6 cases (29%) a history of falling from height was elicited.

For obscure reasons the left elbow was predominantly involved. Literature quotes an incidence of 63% for left side involvement. In this series of 21 cases, 71% (15 cases) involved the left side while 6 cases (29%) involved the right side.

This left :right dominance tested true when compared individually in male and female patients giving again a ratio of 7:3 which is a little higher then the 63% quoted in other studies. An interesting finding was that though the left side was involved in 73% of cases with trivial trauma, in cases with fall from height the figure dropped to 66%.

In this study the peak incidence of injury was in late spring with another peak in late monsoon, which is in conflict with the usual summer peak quoted in literature. Though the summer heat may be claimed to decrease out door activity, this argument can not be sustained as most of the cases succumbed after trivial trauma. One reason for the discrepancy could be the relatively short one year span of study covering only one set of seasons.

For obvious reasons the injury has been described to be more common in boys than in girls in all age groups, except in the very young. In this study 66% of cases were males while 33% were females.

Holmberg (1945)described the grading system which is widely accepted and classifies fractures into 4 types which can be summarized as :

Type I # with displacement

Type II Displacements present but no rotation

Type III Rotation present but fragments still in contact

Type IV Completely displaced.

Gartland (1959) included II & III as Gartland type i.e. displaced but still in contact and IV as # Gartland III.

Bailey & Love claim that 50% are undisplaced type I while of the other 50% half are type II & III (Holemburg) and the other half are type IV. (i.e. 25% each)

In this study of displaced fractures 20 patients were type II, 30% type III while 50% were type IV. Thus half the cases had no contact while the other half were having partial contact which is a finding that appears to be a replica of the distribution fractures quoted in literature.

These fractures are usually associated with trivial trauma & thus simple; the incidence of compound supracondylar fracture of the humerus in children is quoted to be as low as 1% of total cases. Here the study results are in conflict as one case had compound fracture which raised the incidence to 4.8%. However this rise can be attributed to the relatively small size of the study population.

Lal & Bhan (1991) have reported the frequent occurrence in India of late presentation of patients to the hospital. They claim that it is not supporting for patients to seek definitive treatment after much attempts at bone setting by local quacks & bone setters, or even take no treatment at all.

In this series the minimum time of presentation was 2 hrs. while the maximum was 15 days. Two patients (case no. 11 & 12) gave a positive history of massage while in case no. 16 the quack had gone to the limit of applying a POP cast which had

in signs of impending V I C. Most cases (52%) presented on the day of injury and the mode i.e. the central tendency was six hours.

Early complications of the supracondylar fractures though not so common are none the less seen and include neurological, vascular complications and other injuries of the ipsilateral limb.

Studies by Biyani et.al (1989) have shown an annual incidence of 4.3 cases per year of population with supracondylar fractures of the humerus of ipsilateral fracture both bones forearm in their distal quarter, the combination described as the "floating elbow". The injuries were either a fracture of the ulna and radius or the radial epiphyseal separation, at the distal end; the types being present in the ratio of 2:1. In this study there were three cases (no.2,9 &16) of floating elbow and the ratio between fracture and epiphyseal separation of the distal radius was seen in the same ratio of 2:1 (case no. 2 had epiphyseal separation while no. 9 & 16 had fracture of radius). The cases in this study showed no relationship with the severity of supracondylar fractures of the humerus, with various grades being seen in the different cases. This is in agreement with observation by Biyani who found these fractures even in undisplaced supracondylar fractures of the humerus. However one common finding in all cases in this series was the mode of injury, all had suffered trauma after fall from height. Thus one should rule out an associated supracondylar fracture of humerus in cases with fracture of both bone forearm and a history of fall from height .

William son & Cole (1992) have advised pinning of the supracondylar fracture and closed reduction and a below elbow slab for such cases, while Biyani has claimed good results with usual conservative means. In this series only one case (no.2)could be

followed in which there was a fracture separation of the radial epiphysis with fracture ulna, and a grade III supracondylar fractures of the humerus. Both the fractures could be reduced and maintained by an above elbow slab in pronation. On follow up the patient had full range of movements and minimal loss of carrying angle. Of the two other patients with similar injuries one absconded from treatment and the other was lost on follow up. The latter also had a compound fracture of the tibia (case no.9).

Another finding was a right side predominance is the incidence of floating elbow (2:1).

The incidence of neurological complications has been variously quoted between 5 to 17% Dormans JP (1995) found an incidence of 9.5% in his series while Crammer (1993) reports it as 15%. Probably the highest figure quoted has been by Campbell C.C.(1995) who in his series of 59 consecutive cases found the incidence as high as 50% (29 cases).

In this study there were 4 cases (no.4,5,16, & 21) with neurological deficits in (i.e. an incidence of nineteen percent). The increase in the incidence of neurological deficits (that is its detection) has been due to the realization that since most commonly the anterior interosseous branch of median nerve is involved it is difficult to detect it unless one looks out for the deficit. In this study there was a ratio of median nerve : anterior interosseous nerve involvement of 1:3. In all the cases the deficits were diagnosed retrospectively. Other neurological deficits that have been found to be associated with supracondylar fractures of the humerus are ulnar and radial nerves. However, neither of the two deficits were seen in any case in the series. Type III fractures dominated the cases with neurovascular injury (case no.16) and were present

in 75 % of the cases while in one there was a type I fracture. In Campbells (1995) series 87% of the deficits were associated with the anterolateral spiking of the proximal fragment, the same mechanism was probably responsible in 3 cases while in the fourth, with Type I fracture pressure ischemia could have played a role.

All cases in this study were treated by watchful expectancy and all cases that were followed recovered completely by 3½ to 4 months time. Thus all were cases of neuropraxia. Case no.16 absconded from treatment and could not be followed.

Vascular compromise has been stated to be at 5% and the incidence of acute compartment syndrome is reported to be less than 1% of cases with supracondylar fractures of the humerus. In this series of 21 patients there were 5 cases presenting with an absent radial pulse. In case no.9 the medial spike of the proximal fragment had torn through the skin and the artery was found to be divided; both ends had to be ligated to stop the bleeding. However the rich collateral circulation around the elbows that has been described in literature was found to adequately perfuse the distal limb and the extremity remained viable. Case no.16 presented with signs of impending VIC , but absconded and could not be followed.

Of the other three cases in two (case no.2 & 5) there was an immediate return of the pulse on reduction while in case no. 3 it was palpable by the 3rd day. The fractures were of grade III (no.2,3, & 5) or (IV) (no.9) severity except case no.16 which was of grade I. All cases of vascular deficit with displaced fracture were of the extension type.

Various mechanisms described for vascular complications associated with supracondylar fracture of the humerus are the tethering of the brachial artery by the

medial spike of the proximal humerus, its kinking, getting trapped on reduction, acute compartment syndrome or its being torn (either intimal tear or a complete disruptaion). In this series probably the first factor played a role in cases 2,3, & 5 while the last operated in case no 15 presenting with VIC.

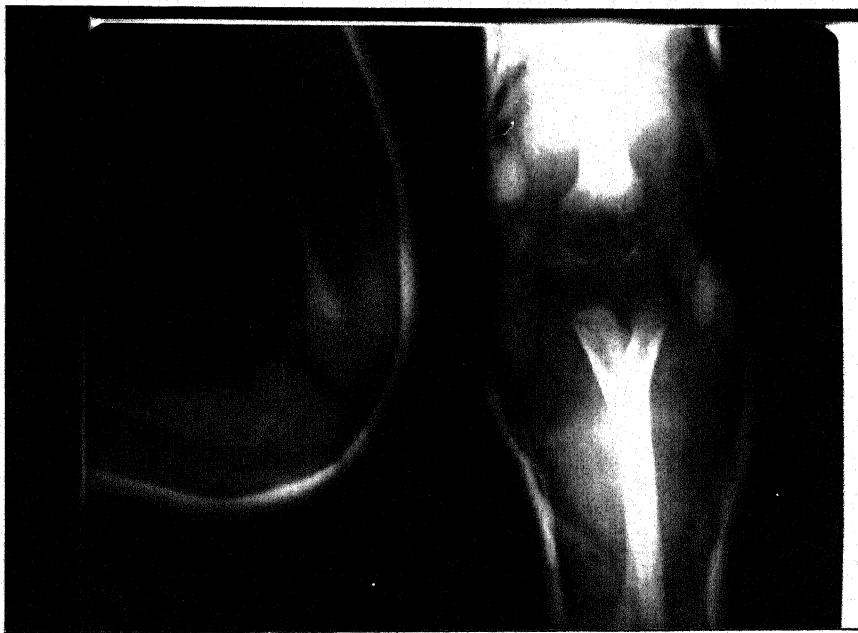
Early reduction has been found to be associated with excellent prognosis as far as neurovascular deficit is concerned, unless there is a true vascular insufficiency with a non viable hand. In this series all patients followed underwent prompt reduction & watchful expectancy & those that could be followed (no. 2,3, & 5) had no residual neurovascular deficit whatsoever.

A complication found this series which is not described in literature was seen with reduction or "over reduction" so to say. In case no.15 a posterior and extension type had been converted by excessive traction to an anterior type. The intial fracture was of type IV (extension type), with the fracture line running obliquely & posteriorly (in the anterior type the fracture line runs obliquely upwards & forwards). The fracture was re-reduced but failed, continuing to be an "iatrogenic" anterior type. The other case was no.17 in which a type II posterior fracture had been converted to a type III posterior fracture.

An issue of great significance today is the length of hospital stay that is associated with the treatement modality chosen. Proponent of conservative methods (i.e.closed reduction maintained by either percutalneous pinning or plaster back slab claim a short hospital stay and one reason why the traction method went into disrepute was that it needed 3 weeks of hospital stay.

However in this series the average duration of stay at hospital was 8-3days.

Results of excessive traction An 'iatrogenic' anterior type.



Photograph 26 : Case No. 15. An initially extension type of fracture was converted to a flexion type due to 'over reduction' Note the oblique fracture line directed upwards and posteriorly. Open reduction was finally sought.

Thus the advantage of short hospitalization period was not seen in this series of conservative management. But a closer look reveals certain factors that led to this.

For one, all cases were maintained by POP cast without a check X-ray during reduction being taken and thus 15 out of the 21 cases needed a second attempt on a different date. The average period of hospitalization for a single attempt at reduction was 4 days while for 2 attempts it was 5.8 days. The longest period of hospitalization was 32 days (cases no. 1 & 2) and both had undergone operative intervention.

A second look at fig. 3 shows another interesting finding. Of the eighteen cases with POP initially applied in supination, seven cases when re-applied in prone position now had acceptable results. Thus one may deduce that if they had been initially maintained in pronation 12.6 (7x1.8) bed days could have been saved.

The results following supracondylar fracture have been evaluated according to various criteria set by Flynn Mitchell & Adams & Henrickson.

According to Watson Jones (1952 - 55) the results following supracondylar fracture are excellent and this series shows similar results.

None of the patients in this series had any restriction of pronation or supination movements. Since this movement involves the superior and inferior radio ulnar joints neither of which are affected in this injury this finding is not surprising !

In this study four patients had a loss of less than five degrees of extension while 3 cases had a loss of more than 10°. Persistent posterior angulation was found to correlate with the loss. Similarly the loss of flexion ranged from less than five degrees in 2 cases to >10° in 3 cases. The flexion & extension loss was greatest in cases with open reduction and internal fixation of the fracture.

Probably the most important cause of worry in supracondylar fractures is the residual deformity due to loss of carrying angle. Lyman Smith in his study of 150 normal children (between ages 3 to 11 yrs) found the carrying angle to be about 6.1° in girls and 5.4° in boys, with a range from 0° to 11° . He also found that 10% had cubitus rectus or no carrying angle. In this series 5.6% had a cubitus rectus and the range was from 0° to 11° . Furthermore, in this study the males had 6.3° a carrying angle of 5.25° on an average while the females had an average of 7 degrees.

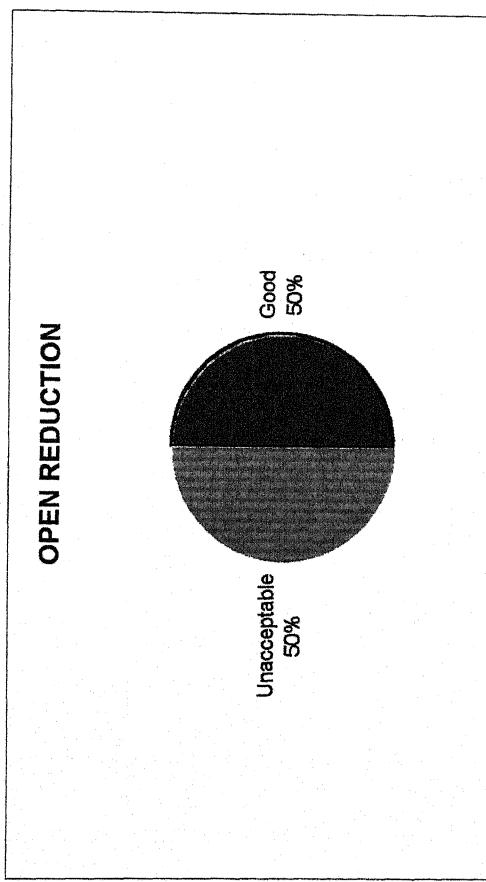
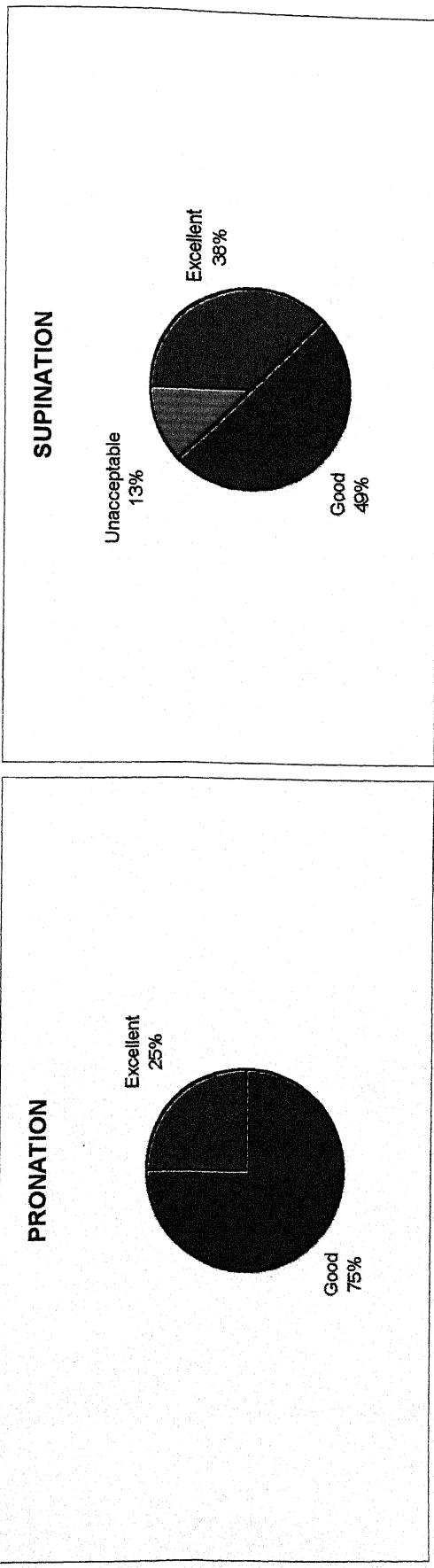
In this study as far as the carrying angle was concerned, in cases in which the forearm was kept in pronation, two cases had a loss of less than 5° while 6 cases had a loss of less than 15° . In cases where the forearm was kept supine after reduction, 3 had a loss of less than 5° while 4 had a loss of less than 15° ; in one case it was 17° .

In two cases treated by open reduction one case had a loss of five degrees while the other had a loss of 20 degrees. The loss was paradoxically greatest in the case treated by open reduction and K wire fixation.

As a whole minimal loss was seen in cases treated with the hand in prone position. These findings are in agreement with the study by Arnold J.A. (1977) who found the best results as far as deformity was concerned, in cases with the hand stabilized in the prone position. According to him internal fixation or the accuracy of reduction achieved does not correlate with the final carrying angle.

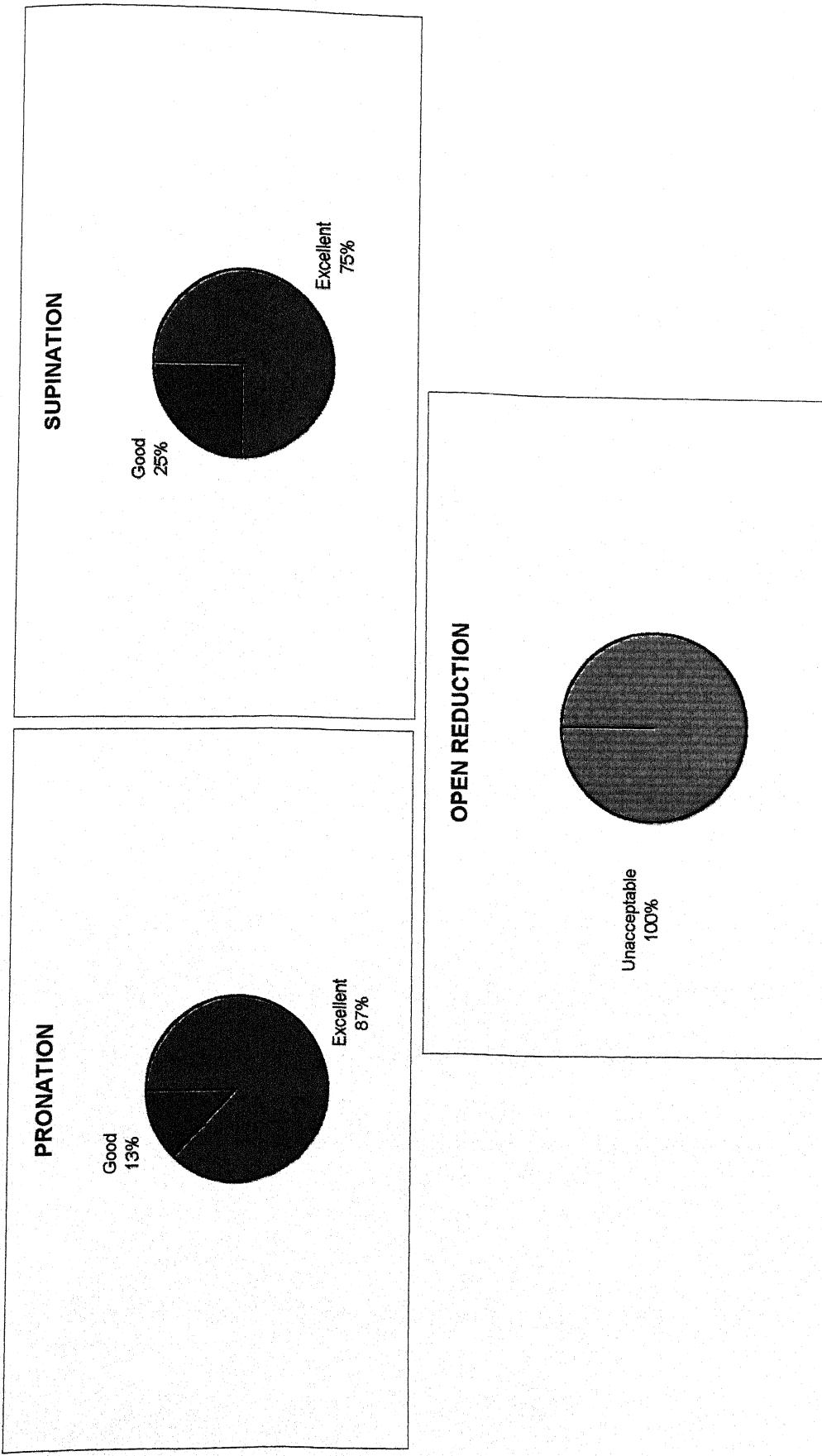
As in this series none of the patients complained of pain, symptoms at work, and muscle contracture or persistent nerve deficit were not found at final evaluation the patients treated by various methods have been tested against the Mitchell and Adams (1961) criteria which is more strict than the criteria set by Henrickson (1960) but

Loss of Carrying Angle in cases treated by various modalities



According to Mitchell and Adams criteria

Loss of Range of Motion in cases treated by various modalities



According to Mitchell and Adams criteria

includes only loss of range of movements and loss of carrying angle for evaluation.

Grade	Supracondylar fracture outcome					
	Degrees change from pre-injury			Range of Motion		
	Carrying Angle		Prone. Supine Open reduction	Prone. Supine Open reduction		Range of Motion
Excellent	2	3	0	7	6	0
Good	6	4	1	1	2	0
Unacceptable	0	1	1	0	0	2

Thus as far as carrying angle is concerned in the prone position 25% patients had excellent results while 75% had good results. In the supine position 37.5% had excellent results and 50% had good results while in one case (12.5%) the result was unacceptable. In the prone group none of the cases had unacceptable deformity. The worst results were seen in cases with open reduction where one had good while the other had unacceptable results and it was in this case that maximum loss in carrying angle occur.

As far as loss of movements was concerned none of the patients with conservative treatment had unacceptable results while both cases with open reduction had poor results. Between the pronation and supination groups the loss of range of movements did not vary significantly.

CONCLUSION

CONCLUSIONS

This study which was conducted at Deptt. of Orthopaedics M.L.B.Medical College, Jhansi comprised of 21 children being admitted to the hospital with the diagnosis of displaced supracondylar fracture of the humerus after presenting at the OPD or Emergency, between the period from mid Sept.96 to Oct.97. The patients were treated conservatively and after reduction an above elbow cast was applied either in pronation or supination. In cases where it was deemed necessary delayed open reduction was done. Following conclusions were drawn from this study.

It is easy to diagnose a case of supracondylar fracture if a true lateral radiograph is taken. However, when the radiograph is not a true lateral one may miss the diagnosis specially in type II fractures.

Hyperextenbility of the elbow is a common finding in children and is present in up to 61% of children and may be even as high as -19° .

The peak age of incidence of this injury is between 6 to 8years of life and is found in children between the age of 4 to 12 years.

The injury occurs most commonly due to minimal trauma which accounts for 71% of the mode of injury while only 29% suffer from this injury after severe trauma.

Left side is involved in 71 % of the cases while the right side is involved in 29% overall. However the left sided dominance is slightly decreases in cases with a history of severe trauma.

The peak season for the injuries is bimodal with one peak in late spring while the other in late mansoon.

The injury is more common in boys who account for 66% of the cases.

Of the displaced fractures 20% are type II 30% are type III while 50% of type IV injuries.

In India the patients often present late to the hospital and may give a history of treatment by local unqualified bone setters.

Ipsilateral injury of both bones of the forearm are not rare and present as either fracture of the distal quarter of both bones or fractures of ulna in combination with fracture separation of the distal radial epiphysis. They may occur with any grade of supracondylar fracture, however a fall from height is usually elicited. Right side is more commonly involved in these cases.

The incidence of neurological complications is about 20% and is most commonly associated with type III fractures. Median nerve is most commonly involved specially its anterior interosseous branch and thus sensory loss is less common than motor loss. The neurological deficit is most commonly a neuropraxia which resolves spontaneously and watchful expectation is adequate.

Vascular complications occur in 5% of the cases and VIC may result from compartments syndrome. However the complete tear of the brachial artery is not necessarily associated with poor prognosis. The absent radial pulse may return immediately after reduction.

Excessive traction during reduction must be avoided. Gentle coaxing of the distal fragment with adequate traction is usually all that is necessary in fresh cases.

If all cases which present with prereduction varus are treated by the prone position of the limb a decrease in hospital stay might be expected in hospitals which lack an x-ray facility in the OT.

The prognosis of displaced supracondylar fracture of the humerus is excellent after treatment with conservative methods irrespective of the position of the limb as far as functions of the elbow are concerned. There is no significant difference in the final functional results which are similar irrespective of the grade of fracture. At the same time open reduction and internal fixation particularly delayed treatment leads to unacceptable results.

The prognosis as far as loss of carrying angle is concerned is best in cases treated with the forearm in prone position. There are never any unacceptable results (i.e. never a loss of more than 15°. However, if the limb is kept in the supine position after reduction there is atleast a one in ten chance of having an unacceptable varus deformity on healing. Open reduction and internal fixation does not guarantee maintainance of final carrying angle.

Thus it may be concluded from this study that closed reduction with prone position of limb in displaced supracondylar fracture of the humerus in children (grade II to IV Holmberg) is an adequate treatment and never leads to an unacceptable varus deformity while preserving functions of the elbow.

APPENDIX

APPENDIX -1

Case No.	Month	Name	Age	Sex	Side	Mode of injury	Diag-nosis	Time b/w inj. & Tt	Other inj./Neurological/Vascular	ACUTE COMPLICATIONS			No. of reduc-tion	Final P.O.P. S/P *	Pd.of hosp. stay	Residual deficits	FINAL EVALUATION					Myositis ossificans
										L	R	U					L / R	L / R	L / R	L / R		
1.	Oct.	Archana	Byr.	F	L	Fall on outstretched hand	II	6hrs.	-	-	-	-	1	S	3days	-	+ / +	+ / +	-4*/-4*	150*/150*	-6*/10*	-
2.	Nov	Roshan	7yr.	M	L	Fall from height	III	3hrs.	#lower 1/4 radius & ulna	Radial pulse absent	2	P	4days	None vasc. on reduction	+ / +	+ / +	-14*/-2*	130*/146*	-1*/6*	-		
3.	Nov	Ashim	6yr.	M	R	Fall on outstretched hand	IV	2days		Radial pulse absent	1	P	3days	None palpable 3rd day	+ / +	+ / +	0*/2*	148*/150*	-5*/3*	-		
4.	Dec	Sunil K.	Byr.	M	L	Fall on outstretched hand	III	5hrs.		Median N. palsy	2	P	7days	None N-nt by 18 weeks	+ / +	+ / +	-3*/0*	130*/136*	-3*/2*	-		
5.	Jan	Ashok	12yr.	M	L	Fall on outstretched hand	III	2hrs.		Ant. Inter- osseous N. pulse absent	3	open reduc-tion	3days	None v-on reduc-tion by 14 weeks	+ / +	+ / +	0*/0*	125*/145*	5*/10*	++		
6.	Jan	Ruby	7yr.	F	L	Fall on outstretched hand	IV	2hrs.			2	P	4days	-	+ / +	+ / +	-2*/0*	142*/144*	4*/8*	-		
7.	Feb	Indresh K.	12yr.	M	L	Fall on outstretched hand	IV	1day			2	S	5days	-	+ / +	+ / +	1*/-19*	136*/116*	1*/10*	+		
8.	Apr	Akhilesh	12yr.	M	L	Fall on outstretched hand	III	4hrs.			2	S	5days	-	+ / +	+ / +	1*/-16*	150*/146*	11*/-4*	-		
9.	Apr	Chandni	7yr.	F	R	Fall from height	IV	4hrs.	#BB forearm & tibia (compd.)	Brachial art. dis-ruption	3	open reduc-tion	13days	-	- / -	- / -	-/-	-/-	-/-	-		
10.	Apr	Suman	6yr.	F	L	Fall from height	IV	4days			1	S	1days	-	+ / +	+ / +	3*/0*	140*/138*	2*/11*	-		
11.	Apr	Rizwan	13yr.	M	L	Fall on outstretched hand	II	15days			1	S	2days	-	+ / +	+ / +	-5*/-2*	145*/147*	-1*/3*	+		
12.	May	Rishi	6yr.	M	R	Fall on outstretched hand	IV	5days			1	S	3days	-	- / -	- / -	-/-	-/-	-/-	-		
13.	May	Pooja	4yr.	F	L	Fall on outstretched hand	IV	2days			2	P	8days	-	+ / +	+ / +	-3*/0*	130*/135*	0*/5*	-		
14.	Jul	Devki Nandan	Byr.	M	L	Fall on outstretched hand	IV	6hrs.			2	S	5days	-	+ / +	+ / +	-6*/-6*	150*/150*	2*/2*	-		
15.	Jul	Neeraj	Byr.	M	R	Fall on outstretched hand	IV	3hrs.			3	open reduc-tion	32days	-	+ / +	+ / +	-2*/0*	145*/125*	2*/-18*	++		
16.	Aug	Rahul	Syr.	M	R	Fall from height	I	7days	#lower 1/4 radius & ulna	Ant. Inter- osseous N. palsy	-	-	12days	-	- / -	- / -	-/-	-/-	-/-	-		
17.	Aug	Rinki	Syr.	F	L	Fall on outstretched hand	II	5days		Impen-ding VIC	2	P	7days	-	+ / +	+ / +	-16*/-5*	130*/138*	1*/4*	-		
18.	Aug	Jitendra	Syr.	M	L	Fall on outstretched hand	II	6hrs.			2	P	7days	-	+ / +	+ / +	0*/0*	140*/140*	10*/10*	-		
19.	Sept	Bandhu	6yr.	M	L	Fall from height	III	1day			1	S	8days	-	+ / +	+ / +	-3*/-3*	146*/146*	-2*/1*	-		
20.	Sept	Ibran	6yr.	M	L	Fall from height	IV	7days			1	S	8days	-	+ / +	+ / +	-2*/-2*	150*/148*	-3*/4*	-		
21.	Sept	Vandana	Byr.	F	R	Fall on outstretched hand	III	4days		Ant. Inter- osseous N. palsy	2	P	6days	None N-nt b. 16 weeks	+ / +	+ / +	-4*/0*	150*/152*	-2*/4*	-		

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